Microplastics and Heart Health | Testing Canine Vocabulary

ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE ■ APRIL 20, 2024

Let It Burn

Collaborative approaches to managing wildfires can reduce the risk of deadly infernos

Urgent: Special Summer Driving Notice

To some, sunglasses are a fashion accessory…

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Sometimes it does take a rocket scientist. A NASA rocket scientist. Some ordinary sunglasses can obscure your vision by exposing your eyes to harmful UV rays, blue light, and reflective glare. They can also darken useful vision-enhancing light. But now, independent research conducted by scientists from NASA's Jet Propulsion Laboratory has brought forth ground-breaking technology to help protect human eyesight from the harmful effects of solar radiation light. This superior lens technology was first discovered when NASA scientists looked to nature for a means to superior eye protection—specifically, by studying the eyes of eagles, known for their extreme visual acuity. This discovery resulted in what is now known as Eagle Eyes®.

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FROM TOP: KATHLEEN DREIER; JULIA D'OLIVIERA; GRZEGORZ ELIASIEWICZ


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Departments

COVER A firefighter works at the site of a controlled burn during the 2022 Fairview Fire in Southern California. *Mario Tama/Getty Images*

Rethinking how we live with wildfires

Fire has been part of life on Earth for a very long time. Bits of charcoal and other wildfire debris have been found in 430-million-year-old rocks, suggesting that plants became fuel for fire shortly after they made their way from oceans to land.

Humans have always had to contend with wildfires, starting long before our ancestors figured out how to make a fire themselves or barbecue a mammoth. As human populations grew, so did the flames' toll. In 1871, the town of Peshtigo, Wis., was leveled by a fast-moving fire that killed about 1,500 people and burned through a swath of forest 15 kilometers wide and 65 kilometers long. The Great Fire of 1910 killed 87 people and burned more than 12,000 square kilometers in Idaho, Montana and Washington. The Cloquet–Moose Lake Fire in 1918 killed 453 people and destroyed 38 towns and villages in Minnesota. The fire that destroyed the historic Hawaiian town of Lahaina in August 2023, killing 100 people and displacing thousands, is just the latest chapter in this long-running tragedy.

Small wonder, then, that people clamor for more protection against fire. The first wildland fire control program in the United States, founded in the Adirondack Mountain Reserve in upstate New York in 1885, called for extinguishing all fires, no matter how small. Since then, wildfire management has cycled through multiple strategies, including total suppression; "prescribed" fires and mechanical thinning to reduce the amount of flammable vegetation; and letting fires burn at will on federal lands.

In this issue, staff writer Nikk Ogasa reports from Arizona and California on a science-driven effort to manage wildfires, known as potential operational delineations, or PODs (Page 22). The concept is simpler than it sounds. It uses data including topography and historical fires to map locations where stopping a blaze would work best. The process also helps identify where homes and other assets would be at risk, and where a burn would be relatively benign.

Local expertise and buy-in is essential, especially with Indigenous communities who have historically been excluded from land management decisions — and who have long practiced controlled burns to improve soils and wildlife habitat, and reduce fire risk.

Working toward consensus on how best to reduce wildfire risk isn't simple or easy, especially when more and more people are being affected by smoke and fire. Because of climate change, wildfire seasons are getting longer. Higher temperatures plus more drought parch soil and vegetation. That makes it easier for fires to spread and harder to extinguish them. Between 1980 and 2023, 22 wildfire events in the United States caused more than $1 billion in damage per fire, according to the National Oceanic and Atmospheric Administration. And the risk continues to build.

We all want to feel safe in our homes, to breathe clean air and enjoy blue skies. As threats from wildfires grow and the number of people who live in harm's way grows, we have to figure out how best to guide the flames.

— Nancy Shute, Editor in Chief

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Excerpt from the April 20, 1974 issue of *Science News*

50 YEARS AGO

Margarine and your heart

Hardening of the arteries causes 90 percent of all heart disease.... The medical community has encouraged people to eat foods with less cholesterol and with poly-unsaturated fats rather than saturated fatty acids. Down with eggs and butter, up with polyunsaturated vegetable oils and margarine!... Now margarine is being accused of being a worse villain ... than butter or eggs.

UPDATE: Margarine's heart healthy reputation melted away because of artificial trans fat. The ingredient, found in processed foods, raises cholesterol levels and was estimated in 2006 to cause up to 1 in 5 heart attacks per year in the United States. New York City soon restricted its use in restaurants, which reduced the city's rate of heart attack (*SN: 5/13/17, p. 8*). Eventually, the United States banned artificial trans fat and the World Health Organization called for eliminating it from the global food supply by 2023. The world did not meet that goal, but at least 57 countries have bans or restrictions in place. Today, U.S. margarine has negligible artificial trans fat.

This parlor roller pigeon has a movement disorder that causes it to backflip on the ground (sequence shown) instead of fly. Scientists are searching for the genes that cause the backward somersaults.

THE SCIENCE LIFE

Why pigeons do backflips

Atoosa Samani started learning about pigeon genetics at a young age. She grew up surrounded by pet pigeons in Isfahan, a city in central Iran famed for its pigeon towers. Her favorite bird was completely white. Yet, Samani noticed, this particular pigeon never fathered all-white offspring.

She learned that all-white coloring is a recessive genetic trait — one that shows up only when an individual inherits two "broken" copies of a gene. In this case, the pigeon had two broken copies of a gene that makes feather pigment, so his feathers were white. But his offspring had colored feathers because they inherited a normal, pigment-producing version of the gene from their mothers.

That early lesson in pigeon heredity stuck with Samani and fueled her desire to learn about genetics. When she moved to the United States to study at the University of Utah in Salt Lake City, she joined Michael Shapiro's lab to investigate why *Columba livia* pigeons do backward somersaults.

Flying rollers such as Birmingham rollers do tumbling runs in the air. Parlor rollers can't fly but instead backflip along the ground. Many Persian poems state the pigeon acrobatics signal the birds are happy. The truth, Samani says, is darker. "This is definitely a movement disorder."

Samani is homing in on the genes behind the disorder, which previous work confirmed is a recessive trait. Using two types of statistical genetic analyses, she found five broad swaths of DNA containing hundreds of genes that could be candidates for causing rolling. Samani then measured gene activity in the birds' brains. Almost 2,000 genes are more or less active in the brains of roller pigeons than in non-rolling birds, she reported March 7 in National Harbor, Md., at the Allied Genetics Conference. Combining all three analyses, she has narrowed the list of candidates to about 300 genes.

Samani will soon finish her Ph.D. and hopes to start a teaching career. She'll miss the pigeons and the mental exercise they gave her, she says. "I have been thinking about this for five years. I have a piece of puzzle here. I have a piece of puzzle there. How can I put them together so that they make sense? Do they actually fit together? That's the thing I will miss the most," she says. "I love solving mysteries."

— Tina Hesman Saey

Pigeon geneticist Atoosa Samani holds a Wilson's warbler.

UNIV. OF UTAH GENETIC SCIENCE LEARNING CENTER; COURTESY OF A. SAMANI

FOR DAILY USE

Don't rinse your nose with unsterilized water

Nasal rinses can relieve sinus congestion. But using the wrong liquid may, in rare cases, give people infections with deadly brain-eating amoebas.

Washing sinuses with water straight from the faucet may expose people to *Acanthamoeba* and *Naegleria fowleri*, single-celled organisms commonly found in lakes and rivers. The amoebas may enter the brain through the nose, but drinking contaminated water won't result in infection.

Nasal rinsing is the likely source of 10 *Acanthamoeba* infections in the United States over the last decade, three of which were fatal, the Centers for Disease Control and Prevention reports March 12 in *Emerging Infectious Diseases*. Though the cause hasn't been definitively established, four people reported using unsterilized tap water. One person used sterile water but then dunked the rinsing device (like the one shown) in unsterilized water. The type of water used in the other cases is unknown.

A separate study in the same issue of *Emerging Infectious Diseases* describes how a 22-year-old man in Pakistan got an *N. fowleri* brain infection, which is almost always fatal, after rinsing his sinuses with tap water during a religious ritual. Early diagnosis and aggressive treatment saved his life, making the man one of eight known survivors of such infections.

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Known survivors of *N. fowleri* brain infections

Researchers advise people who rinse their sinuses to use distilled or sterile water, or tap water that has been boiled for five minutes and cooled. —*Tina Hesman Saey*

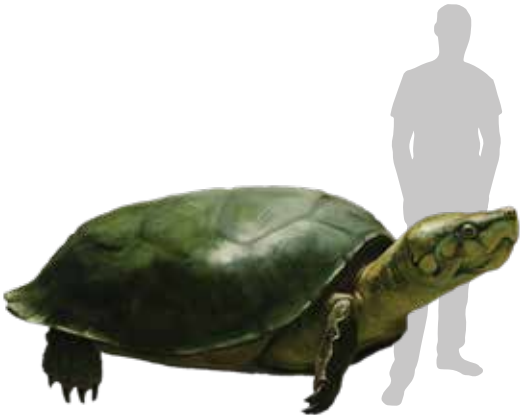
THE EVERYDAY EXPLAINED

These chemicals give teens strong body odor

Puberty changes just about everything. Bodies get taller, muscles get stronger and often, body odor becomes more pungent. Now, scientists have identified some of the compounds that give teenagers their natural aroma.

Unlike that of infants and toddlers, teenage body odor has two smelly steroids and higher levels of carboxylic acids, researchers report March 21 in *Communications Chemistry*. Those chemicals form when armpit sweat and sebum—the oily secretions that keep our skin moist—break down, and may contribute to the noticeable changes in BO throughout puberty.

Chemist Helene Loos of the University of Erlangen-Nuremberg in Germany and colleagues collected body odor samples from 18 teens and 18 children age 3 and under who had slept with cotton pads under their arms for a night. Separating the body odor into individual components revealed that young children and teens have over 40 compounds in common. But carboxylic acids were more prevalent in teens. These were a mix of pleasant scents, described by an expert panel as fruity, soapy or grassy, and acrid ones that smelled cheesy, musty or goatlike. The team also found two steroids present only in the teens' body odor. Those compounds smell of sweat, musk, urine and sandalwood. —*Skyler Ware*



INTRODUCING

Extinct giant turtle may have run into humans

As little as 9,000 years ago, a sofa-sized turtle paddled around the Amazon. The finding, based on a fossilized jawbone, reveals that one of the most massive turtles ever lived relatively close to the modern day. The turtle lived so recently, in fact, it's possible that people in South America encountered it, scientists report in the March *Biology Letters*.

Uncovered in 2007 near Porto Velho, Brazil, the fossilized remains were determined to be part of a turtle's lower jaw. "I was very excited because of its size, so we managed to bring the specimen to our lab" at the University of São Paulo, says paleontologist Gabriel Ferreira.

Comparing jawbone measurements with both living and extinct turtles let Ferreira and colleagues not only estimate the size of the reptile (illustrated above), but also determine it is a newfound species. The team named it *Peltocephalus maturin*—a reference to a cosmic turtle character in several Stephen King novels. *P. maturin*'s shell would have been nearly 2 meters long, Ferreira says, making the reptile one of the largest turtles to ever exist and the second largest freshwater turtle.

Radiocarbon and geochemical analyses suggest *P. maturin* lived between 46,000 and 9,000 years ago. That's unusual because similarly sized freshwater turtles all lived millions of years ago. Archaeological evidence suggests humans inhabited the Amazon over 11,000 years ago, so it's possible they came across *P. maturin*. —*Jake Buehler*

CLOCKWISE FROM TOP LEFT: TARA MOORE/DIGITALVISION/GETTY IMAGES; DUCKYCARDS/ISTOCK/GETTY IMAGES PLUS; JULIA D'OLIVIERA, SENCKENBERG SOCIETY FOR NATURE RESEARCH; MIKHAIL SELEZNEV/ISTOCK/GETTY IMAGES PLUS

HEALTH & MEDICINE

Tiny plastics turn up in arterial clogs

Finding renews concerns about the materials' effects on health

BY MEGHAN ROSEN

Tiny flecks of plastic inside arteries may ramp up the risks of cardiovascular disease.

An analysis of artery-clogging plaques in 257 patients found that the presence of plastics was associated with a roughly quadrupled risk of heart attack, stroke or death, researchers report in the March 7 *New England Journal of Medicine*.

The extent of that enhanced risk is stunning, says cardiovascular researcher Aruni Bhatnagar of the University of Louisville in Kentucky. When it comes to factors that drive cardiovascular disease, "very, very, very few things have that much of a risk."

The study has renewed concerns about the effects of plastics on human health and is one of a growing number of reports that have found microscopic plastic particles in the body, including in the lungs, liver and blood (SN: 3/25/23, p. 22).

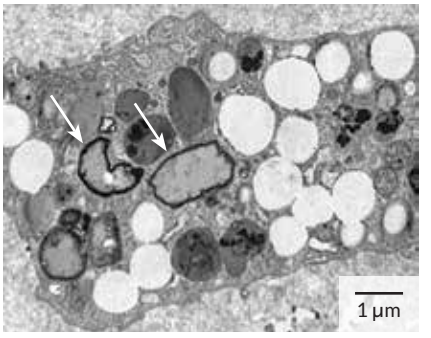
But whether these particles actually harm people remains unclear. The study places the particles at the scene of the crime, Bhatnagar says, but there's not enough evidence for an indictment just yet. Though the new results are "certainly cause for concern," he cautions, "we have to be careful not to create mass hysteria."

When plastic toys, pipes, containers and other objects break down over time, they shed infinitesimal particles into the environment. Microplastics, which are smaller than a peppercorn, and nanoplastics, which are roughly one five-thousandth that size, can travel into our bodies via food and drink, the air we breathe and even directly through the skin.

Our exposure to microplastics will only go up as old plastics deteriorate and enter the ecosystem, and plastic production continues to surge, says environmental toxicologist Matthew Campen of the University of New Mexico in Albuquerque. His team has reported finding microplastics in human placenta, testicular and brain tissues. The plaque study adds to a rapidly emerging picture of how plastics may affect our health, Campen says.

Cardiovascular researcher Francesco Prattichizzo of IRCCS MultiMedica in Milan and colleagues examined plaques from patients who had surgery to clean out their carotid arteries, blood vessels in the neck that carry blood to the brain. "More than half of patients had evidence of at least one type of plastic," Prattichizzo says.

These patients' plaques all contained polyethylene, a material used in cling wrap, cutting boards and other household items. And 12 percent of patients also had PVC, or polyvinyl chloride. Of 150 people with evidence of plastics, 30 died or had a nonfatal stroke or heart attack within about the next three years. That's compared with eight out of 107 people whose plaques appeared plastic-free, the team reports.



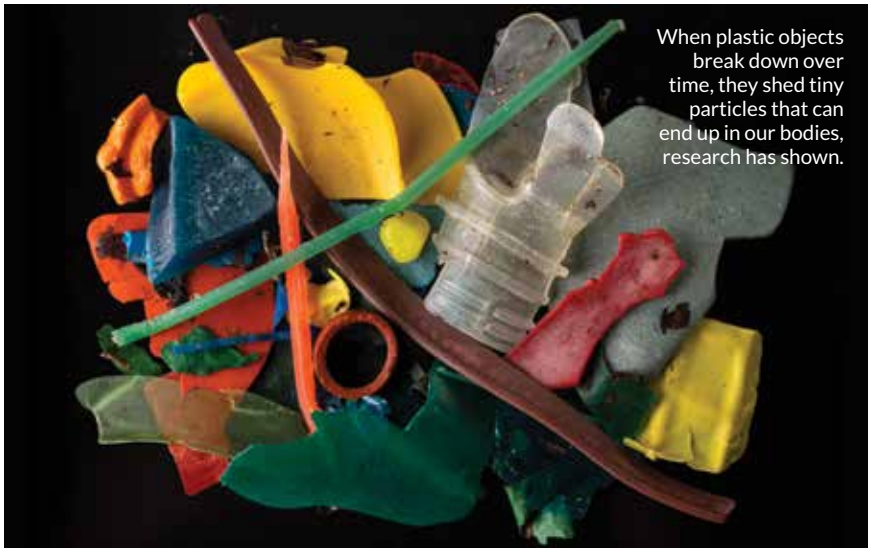
In plaques cleared from inside human arteries, scientists found jagged particles (indicated by arrows in this transmission electron microscope image) that may be bits of plastic.

It's possible that plastics inside arteries drive inflammation, further kindling cardiovascular disease. Plaques with plastic tended to contain more inflammatory molecules than plastic-free plaques, the team found. But Prattichizzo stops short of concluding that the plastics are harmful. His team simply exposed a link between plastics in plaques and poor outcomes in patients, he says.

Studying plastics is tricky, says toxicologist Juliette Legler of Utrecht University in the Netherlands. Floating motes in the environment could easily hitchhike into experiments. "Plastics are everywhere in our labs.... They're everywhere in the hospital," she says. The team used cotton gloves and glassware in the study, but Prattichizzo can't exclude the possibility of contamination. That's why it's important to replicate the results, he says, in even larger groups followed for longer periods of time.

Confirming the link between plaque plastics and health outcomes is essential, Legler says. It might mean that reducing plastic in the environment would reduce the risk of stroke or heart attack.

But there are plenty of other reasons to reduce the use of plastics, Prattichizzo says. There's no need to wait to find out whether they drive heart attacks, too. ■



When plastic objects break down over time, they shed tiny particles that can end up in our bodies, research has shown.

FROM TOP: R. MARFELLA *ET AL/NEW ENGLAND JOURNAL OF MEDICINE* 2024; DAN KITWOOD/GETTY IMAGES

Earth's polar ice sheets — including ice atop Greenland (shown) — are rapidly melting, slowing the planet's spin and thus affecting global timekeeping.

KEREM YUCEL/AFP VIA GETTY IMAGES

CLIMATE

Global warming disrupts timekeeping

Ice loss is slowing Earth's rotation, affecting how time is measured

BY CAROLYN GRAMLING

Climate change might be making it harder to know exactly what time it is.

The rapid melting of the ice sheets atop Greenland and Antarctica, as measured by satellite-based gravitational measurements, is shifting more mass toward Earth's waistline. And that extra bulge is slowing the planet's rotation, geophysicist Duncan Agnew of the Scripps Institution of Oceanography in La Jolla, Calif., reports March 27 in *Nature*. That climate change–driven mass shift is throwing a new wrench into international timekeeping standards.

The internationally agreed-upon coordinated universal time, or UTC, is set by atomic clocks and is regularly adjusted to match Earth's spin. That's because the planet's rotation isn't always smooth sailing. The speed changes depending on a variety of factors, including gravitational drag from the sun and the moon, changes to the rotation speed of the inner core, friction between ocean waters and the seafloor, and shifts in the distribution of mass around the surface.

Even earthquakes can affect the spin. For example, the magnitude 9.1 earthquake in Sumatra in 2004 altered the land surface in such a way that it caused Earth to rotate a tiny bit faster, Agnew says. But the impact of that quake is much smaller than that of the ice sheets' melting — a point that Agnew finds particularly startling.

Humankind "has done something that affects, measurably, the rotation rate of the entire Earth," Agnew says.

The need for occasional tweaks to the synchronization of atomic clocks and Earth's rotation gave birth in 1972 to the "leap second," an extra tick that international timekeepers agreed to add to UTC as needed. Timekeepers have added 27 leap seconds to the clock since the idea was introduced.

> Climate change–driven mass shift is throwing a new wrench into international timekeeping standards.

Measurement scientists, or metrologists, aren't fond of this system. For one thing, it doesn't happen on a regular schedule, only whenever it seems to be needed. And financial markets and satellite navigation systems, which rely on precise timing, each have their own methods of incorporating a leap second.

Those inconsistencies make it more challenging to have a universal time. So in 2022, an international consortium of metrologists voted to do away with leap seconds in favor of adding larger chunks of time, perhaps a minute, less frequently (SN: 1/13/24, *p.* 4). The group resolved to settle the details at its next meeting in 2026.

But timekeepers will have to come to a reckoning soon. Currently, the biggest changes to Earth's rotation are coming from the planet's heart. In recent decades, slowing rotation of the core has been speeding up the spin of the outer layers (SN: 2/25/23, *p.* 7). As a result, Earth's rotation and atomic clocks are now almost in sync — timekeepers haven't had to add a leap second to UTC since 2016.

But by 2029, Earth's spin will increase enough that timekeepers may have to begin removing, rather than adding, leap seconds (if the convention hasn't been replaced). The mass shift from rapidly melting ice sheets has bought a few years by countering the speedup from the core, Agnew says. Without this effect of climate change, that adjustment would have happened as soon as 2026.

Still, no realistic projections of future melting can forestall the inevitable need for timekeeping adjustments before 2030, says Jerry Mitrovica, a geophysicist at Harvard University who was not involved in the study. One way or another, Mitrovica says, the world is going to have to start losing time — or the way that we keep time is going to have to change. ■

PHYSICS

Gravimeters keep getting smaller

Phone-sized device measures subtle changes in gravity

BY ADAM MANN

There's a new entrant in the competition to develop ever-smaller instruments that can detect changes in Earth's gravitational field — a tabletop device roughly the size of two smartphones stacked together.

The instrument has been used to measure the Earth's tides over several days, physicist Pu Huang of Nanjing University in China and colleagues report in the March 22 *Physical Review Letters*.

Researchers have long sought to build lightweight gravity-measuring instruments. Called gravimeters, such devices can detect the movement of tectonic plates and groundwater, reveal oil and gas reserves, and track magma within volcanoes, along with other applications.

Yet most instruments with enough sensitivity for such monitoring remain stuck inside of labs, requiring bulky equipment to create protective vacuums or cool parts to extremely low temperatures. Portable gravimeters are often the size of household appliances. But far smaller ones exist, including a prototype for a postage stamp–sized gravimeter with enough sensitivity for some basic geophysics applications. The new device, though larger, is about three times as sensitive.

The strength of gravity between two objects depends on their masses and the distance between them. Gravitational changes can therefore be measured by something like a weight on a spring. If such an apparatus is moved closer to or farther from the ground, or over abrupt changes in the terrain's density, Earth's gravitational pull on the weight will change, and the length of the spring will correspondingly change very slightly.

Instead of a weight and spring, Huang and colleagues used two magnets, one levitated by the other. The levitated magnet acted like the weight, moving up and down in response to a shifting gravitational field. Magnetism between the magnets worked akin to the solid spring. A laser measured changes in the position of the levitated magnet, allowing the team to watch Earth's gravitational field fluctuate over several days in response to tidal forces from the moon. The device also detected two earthquakes, one in the Pacific Ocean off Japan and one in the Bali Sea off Indonesia.

The device is not as sensitive as the world's best portable gravimeters, says physicist Xuejian Wu of Rutgers University in Newark, N.J. Such devices can detect gravitational field changes of around 1 part in a billion, whereas this one does to about 1 part in 60 million.

Huang plans to up the sensitivity while shrinking the device even further. Most of its bulk comes from magnetic shielding. The device's heart — the levitated magnet — is smaller than a grain of rice and weighs less than two coffee beans. Within a couple years, the device could be the size of a computer chip, Huang says. ■

ARCHAEOLOGY

Brains found at archaeological sites are surprisingly well-preserved

Early in her career, forensic anthropologist Alexandra Morton-Hayward of the University of Oxford came across a paper describing a 2,500-year-old brain preserved in a severed skull. The paper referenced another preserved brain. She found another report. And another. By the time she'd reached 12, she noticed that the papers tended to describe the brains as a unique phenomenon. She kept digging.

Naturally preserved brains, it turns out, aren't so rare after all, Morton-Hayward and colleagues report in the March 27 *Proceedings of the Royal Society B*. The researchers have built an archive of about 4,400 human brains preserved in the archaeological record, some dating to roughly 12,000 years ago. The archive includes brains from Inca sacrificial victims, North Pole explorers and other people around the world.

Because scientists have considered preserved brains exceptionally rare, little research has been done on them. "If they're precious, one-of-a-kind materials, then you don't want to analyze them or disturb them," Morton-Hayward says. Less than 1 percent of the archive has been studied.

A look at historical climate patterns of the locations where the brains were found hints at what might keep the organs from decaying. Over a third of the samples persisted because of dehydration; others were frozen or tanned. Depending on the environmental conditions, the preserved brains' textures can be anything from dry and brittle to squishy and tofulike. The brain shown below, excavated from a grave in a 10th century Belgian churchyard, is soft, wet and stained orange with iron oxides.

A.L. MORTON-HAYWARD

About a quarter of the brains came from bodies without any other preserved soft tissue. Just bones and "this shrunken perfect little brain rattling around in a skull," Morton-Hayward says.

Why brains persist when other soft tissues degrade is unclear. The team is now investigating the molecular underpinnings of brain preservation. — *Nora Bradford*

NASA, ESA, MASSIMO ROBBERTO/STSCI AND ESA, HUBBLE SPACE TELESCOPE ORION TREASURY PROJECT TEAM

Interstellar clouds such as the Orion Nebula (shown in this image from the Hubble Space Telescope) could be birthplaces of glyceric acid and other molecules important for life.

ASTRONOMY

Interstellar clouds may cook up sugar

Recipe includes ethylene glycol, carbon dioxide and radiation

BY SAUGAT BOLAKHE

Researchers may have figured out how a crucial ingredient that cells need to produce energy could form in deep space.

Calculations and lab experiments suggest that glyceric acid can arise from radiation blasting carbon dioxide and ethylene glycol in interstellar clouds, theoretical astrochemist Ryan Fortenberry of the University of Mississippi near Oxford and colleagues report in the March 15 *Science Advances*.

The study is "a great start to understand how these molecules are formed in space," says astrochemist Anthony Remijan of the National Radio Astronomy Observatory in Charlottesville, Va. The finding suggests that "if you put the right mixture together, in the right conditions, maybe you can even afford more complex molecules in space."

Glyceric acid plays an important role in cell metabolism and photosynthesis, and it can go on to help form other complex molecules important to life. The acidic sugar has previously been found in meteorites, suggesting that it can form in outer space. Astronomers have yet to directly observe glyceric acid in space, but they suspect it may form in interstellar clouds such as the Orion Nebula, which roils with gas, plasma and dust.

Chemists can use data on the gases in these clouds to predict what happens when the gases are blasted by cosmic rays and other sources of radiation. The approach has led lab scientists to demonstrate how the simple sugar ribose, a key component of RNA, could be made in interstellar conditions (*SN*: 4/30/16, *p.* 18).

So the new study began with a question: "Can we synthesize [glyceric acid] at low temperature and low pressure, like we get in space?" Fortenberry says. "We think we can."

Fortenberry and colleagues started by looking into the properties of two compounds that are abundant in interstellar clouds — carbon dioxide and ethylene glycol, commonly known as the active ingredient in antifreeze.

Computer calculations of how CO_2 and ethylene glycol respond to radiation suggest that they could team up to form glyceric acid in space. To verify the theoretical results, physical chemist Ralf Ingo Kaiser of the University of Hawaii at Manoa and colleagues deposited ices of carbon dioxide and ethylene glycol in a vacuum chamber at extremely low pressure and temperature. The team then blasted the compounds with radiation.

"We cannot generate galactic cosmic rays in our lab," Kaiser says. So the researchers opted for the next best thing: spraying the compounds with electrons to simulate the shower of charged particles that's triggered when cosmic rays hit ice. As the ices transitioned to vapor, the team blasted the chamber with ultraviolet radiation, which resulted in the formation of glyceric acid molecules.

"It's not magic," Fortenberry says. "But it feels like magic because you get these biologically significant species from really mind-blowingly simple molecules."

While simple organic compounds are easily observed in many cosmic environments, complex organics are harder to find. The study provides an understanding of "how much that very simple chemistry that we can observe can evolve into something more complex," says Stefanie Milam, an astrochemist at NASA's Goddard Space Flight Center in Greenbelt, Md.

A next step, Fortenberry's team says, is to search interstellar clouds for glyceric acid. Astronomers could use the Atacama Large Millimeter/submillimeter Array in Chile, which has helped find phosphorus-bearing molecules and others important for life in the cosmos (*SN*: 2/15/20, *p.* 12). ■

The tree frog *Pithecopus rusticus* is known from only one small population in Brazil. A search for more of the frogs turned up traces of DNA from the American bullfrog, an invasive species in Brazil that may pose a threat to the tree frog.

ANIMALS

Rare tree frog may face a furtive foe

Environmental DNA reveals the presence of a bullfrog threat

BY JOSHUA RAPP LEARN

American bullfrog DNA has turned up near the only known habitat of a small, critically endangered tree frog that lives in Southern Brazil.

Bullfrogs are native to the eastern United States but invasive elsewhere. Finding genetic traces of them in the high-elevation grasslands of Santa Catarina state could spell trouble for *Pithecopus rusticus* tree frogs, researchers report in the March *Journal for Nature Conservation*.

These green, orange and black frogs are small — no bigger than a golf ball. Since discovering the species in the Água Doce municipality in 2009, scientists have found just one population, thought to number less than 30 frogs.

"With rapid habitat degradation and a small population size, there is an urgent need to find additional populations for conservation efforts," says Julia Ernetti, an ecologist at the State University of Campinas in Brazil.

That's why she and colleagues tried searching for signs of *P. rusticus* DNA in the environment. During the 2020 amphibian breeding season, the team collected 24 water samples in and around the Wildlife Refuge of Campos de Palmas, which is about two kilometers from where the species was discovered. Though the refuge has comparable conditions, it's separated from the known population by a highway.

An analysis of the samples didn't find *P. rusticus* DNA, but it did reveal American bullfrog DNA — hinting that that species, *Lithobates catesbeianus*, may reside in the refuge. While startling, the finding is perhaps not unexpected. Farmers brought the bullfrogs to Brazil in 1935 to raise for human consumption, Ernetti says, and there are both farmed and wild populations in Santa Catarina.

Still, the situation is alarming, says

ANIMALS

Birds flutter wings to say 'after you'

Japanese tits gesture to send mates a complex message

BY DARREN INCORVAIA

Be it an arched eyebrow, a shaken head or a raised finger, humans wordlessly communicate complex ideas through gestures every day. This ability is rare in the animal kingdom, known primarily among primates. But scientists might be able to add a feathered friend to the club.

Researchers have observed Japanese tits making an "after you" gesture: A bird flutters its wings, cuing its mate to enter the nest first. The finding, reported in the March 25 *Current Biology*, "shows that Japanese tits not only use wing fluttering as a symbolic gesture, but also in a complex social context involving a sender, receiver and a specific goal, much like how humans communicate," says biologist Toshitaka Suzuki of the University of Tokyo.

Suzuki has been listening to the calls of Japanese tits (*Parus minor*) for nearly 20 years. During his time in the field, he has noticed that Japanese tits bringing food to the nest sometimes perch on a branch and flutter their wings. At that point, their partners enter the nest with the flutterer close behind. "This led me to investigate whether this behavior fulfills the criteria of gestures," Suzuki says.

Suzuki and Norimasa Sugita, a researcher at Tokyo's National Museum of Nature and Science, observed eight mated pairs make 321 trips to their nests over 11 days. A pattern quickly emerged. Female birds fluttered their wings far more often than males, with six females shaking it up while only one male did. Females almost always entered the nest first — unless they fluttered their wings. Then the males went first.

The birds also "never flutter their wings when they visit the nest alone," Suzuki says. Fluttering happens only when birds are in the company of their mates, and they seem to direct their fluttering at their mate rather than at the nest entrance. This observation suggests that the Japanese tits aren't pointing — a simple gesture that's previously been seen in birds such as magpies and ravens, and is meant only to direct attention — but rather are communicating a complex message.

"I might think of this as an imperative

ELAINE LUCAS

Watch a video of a bird gesturing at **bit.ly/SN_PoliteBirds**

wildlife biologist Nathan Snow of the U.S. Animal and Plant Health Inspection Service in Fort Collins, Colo. "Bullfrogs are the ultimate invaders: They are generalist and voracious eaters, they outcompete native amphibians for food resources, and they reproduce prolifically."

Along with competing for food and territory, American bullfrogs could spread diseases like chytrid fungus, a pathogen that has wiped out entire populations of amphibians across the Americas. The bullfrogs' call also overlaps and may interfere with those of several native species in the area. "Any interference with this communication could directly impact [native species'] reproductive success, potentially leading to population declines and an increased risk of extinction," Ernetti says.

Bullfrogs are also known to eat small frogs like *P. rusticus*, though there are no signs, yet, that the rare tree frog is on the menu. *P. rusticus*' existence is so fragile that any losses due to bullfrogs would be a big problem, Ernetti says.

However, stopping bullfrogs from invading *P. rusticus* habitat might be easier said than done. Once established, bullfrogs are very difficult to get rid of. For amphibians native to sensitive ecosystems, Snow says, a bullfrog invasion "could be devastating." ■

gesture, a movement that communicates to another individual that they need to do something," says primatologist Kirsty Graham of the University of St. Andrews in Scotland.

"It's really exciting to uncover meaningful gestures in another species," Graham says. "I expect that we'll probably find gesturing to be more widespread than previously thought."

Gesturing by the nest instead of calling may help the birds avoid attracting predators, Suzuki says. He next wants to find out how wing fluttering fits into the tits' larger communication repertoire. "In humans, gestures are used in combination with spoken language," he says. "We are interested in understanding messages created by the combination of gestural and vocal communication in animals." ■

GRZEGORZ ELIASIEWICZ

ANIMALS

Dogs know words for specific toys

Brains signaled surprise when owners held up the wrong item

BY LAURA SANDERS

Dogs may know more than they let on. Pet dogs' brains displayed neural signs of surprise when their owners showed them an unexpected toy. The findings, published March 22 in *Current Biology*, suggest that dogs create mental concepts of objects.

"Anyone who has ever interacted very much with a dog probably is not that surprised to know that dogs understand that your speech is referring to at least a few common objects," says Ellen Lau, a neuroscientist at the University of Maryland in College Park. But some people may have assumed this "understanding" is a simple reaction to the sound of the word.

Marianna Boros, a neuroscientist and ethologist at Eötvös Loránd University in Budapest, and colleagues recruited 27 pet dogs and their owners. This motley crew included a toy poodle, an akita, a Labrador and mixed breeds. The team asked the owners to bring five familiar toys and other objects, such as leashes, to the lab. Researchers stuck electrodes to the pooches' heads and gave the pups two tasks: lie on a mat and stay awake.

Every so often, a dog would hear a recording of its owner saying things like, "Kun-Kun, look, the ball!" The dog's human was on the other side of a wall with an electronic window that could change from opaque to transparent. Just after the audio played, the window would reveal the owner holding a toy — the ball or a different toy, such as a rope.

Just after seeing an unexpected object, an electrode monitoring brain activity picked up a larger-than-normal signal. This signal indicates surprise, the team says, and suggests that the dog had already formed a mental concept and expectation of the ball after hearing that word. In fact, the signal was especially strong for a mismatch involving words that the dogs reportedly knew very well. "That suggests that it is really about understanding and knowledge of the word," Boros says.

Humans have this surprise signal, too. Called the N400 effect, it occurs in the brain just after something unexpected happens. There are thousands of studies in humans using this N400 effect, Lau says. But there has been no evidence of a similar signal in dogs, until now.

The new work gives a glimpse into the mental lives of dogs that didn't exist before, Boros says. "We can say that they know passively the words." ■

Electrodes on the head of this dog and others recorded neural signals of surprise when the canines were shown unexpected toys. The finding suggests dogs form mental concepts of nouns.

PLANTS

Flowers might gossip via electric fields

Plants sense bees' electrical signals and alert neighbors, tests hint

BY RACHEL BERKOWITZ

Flowering plants may have a secret power for knowing when to lure pollinators.

Their flowers could act as antennas for bees' electrical signals and transmit those signals to the soil, biophysicist Daniel Robert reported March 6 in Minneapolis at the American Physical Society meeting. The finding offers a possible clue to how floral neighbors share information about when to produce nectar, saving energy for when pollination looks promising.

If a bee's flapping wings trigger even a small voltage difference in plants, it could be "an interesting demonstration of communication," says biomechanics researcher Víctor Ortega-Jiménez of the University of Maine in Orono.

Researchers have long proposed that plants have a form of electrical communication. "This process implies information exchange that's much faster than chemical communication," says Robert, of the University of Bristol in England. But how plants' electrical communication works and whether it links species and organisms that have a presence above and below ground remains a puzzle.

Robert and colleagues had previously found that bumblebees carry a positive electric charge, while flowers carry a negative one. In petunias, stems not only become more negatively charged when a bee approaches, but their flowers also increase scent production—hinting that the plant can detect pollinators based on a noncontact electrical signal.

In the new study, ecologist Fraser Woodburn, who works in Robert's lab, designed antennas to give off signals that mimic those produced by a bee's wings flapping in an electric field. The antennas were placed above daffodils cultivated in the lab. The team also placed electrodes on stems. By measuring the variation in voltage at the stem surface, the researchers could infer if the plants could detect the signal.

Daffodils, the results suggest, could receive electrical signals from the antennas without physically contacting them. Changing the flower's shape by removing the center trumpet or petals reduced the daffodil's signal-receiving ability, the team reports, perhaps by making it less of a "dish."

Next, the researchers took the work outside, to hogweed plants and buttercups in the University of Bristol gardens. The team again mimicked sending bees' electrical signals above a row of flowers outfitted with electrodes. Nearby flowers in the same soil also donned electrodes, but those plants were covered with a metal shield to block any electrical or chemical signals in the air.

Surprisingly, the electrodes on the shielded plants detected electrical signals, suggesting the plants passed them underground. Those signals maintained their strength even on plants farther away from the initial beelike signal.

"What is extraordinary about this work is that it suggests that plants perhaps talk to each other through electric fields," says physicist Scott Waitukaitis of the Institute of Science and Technology Austria in Klosterneuburg.

The team stops short of saying that plants use these electrical signals, says Waitukaitis, who studies electrical exchanges between objects. This idea, though far-fetched, "is not entirely out of the realm of reason, and more work should certainly be done," he says.

Biophysicist and botanist Ingo Dreyer of the University of Talca in Chile is skeptical of the result. A flying bee "hardly exchanges charges with its environment," Dreyer says. What's more, the input signal in the experiments was 10 volts while the detected signal was less than 20 millivolts—roughly one five-hundredth the strength of the original. That raises questions about transmission, he says.

The weak, detected signal, Robert says, indicates "a slow conductive process, but nonetheless conductive." The signal could be transmitted underground to other plants through electrolytes, wet soil or fungus, he says. Still, the general consequences of that conduction are not clear.

The exchange could ultimately help plants conserve energy, Robert says. Making nectar to attract pollinators is expensive. Finding a way to time production to when pollinators are present could pay off. ■

When a bee approaches a buttercup, the flower can sense electrical changes triggered by the insect's flapping wings and alert nearby plants via its own electrical signals, new research suggests.

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HEALTH & MEDICINE

Sweat may offer Lyme protection

Protein in perspiration kept bacteria from infecting mice

BY ERIN GARCIA DE JESÚS

Ticks transmit a bacterium that causes Lyme disease. In lab tests, a protein in human sweat stopped the pathogen from infecting mice.

Breaking into a cold sweat over a tick bite may have its benefits. A protein found in human perspiration could offer some protection against *Borrelia burgdorferi*, a tick-transmitted bacterium that causes Lyme disease, scientists report March 19 in *Nature Communications*. In lab dishes and mice, the protein curbed bacterial growth.

Common risk factors for contracting Lyme include camping, golfing and maybe gardening, says MIT immunologist Michal Tal. But sweaty activities like trail running aren't typically on the list. "It's never even been a question of whether or not it mattered if you were sweating, and if you had any protection in your sweat," she says.

Tal and colleagues aimed to find genes that may make some people more susceptible to Lyme disease. The team analyzed genetic data from nearly 620,000 people who'd been seen at hospitals or primary care clinics in Finland and Estonia. More than 25,000 of those individuals had been diagnosed with Lyme disease.

The analysis uncovered three candidate genes. Two genes provide the instructions to make immune proteins that help the body identify foreign invaders. The third gene codes for SCGB1D2, a protein "that we didn't really know anything about," says geneticist Hanna Ollila of the University of Helsinki. The team eventually figured out that SCGB1D2 is made in sweat glands and may show up on the skin, the first line of defense against hungry ticks.

In lab dishes, the protein stopped *B. burgdorferi* from growing. What's more, mice injected with the protein plus the bacteria didn't become infected.

However, 40 percent of people in the study carried a mutated version of the protein. In experiments with that variant, twice as much protein was required to curb bacterial growth in lab dishes. And mice injected with the variant alongside the bacteria developed infections.

The results suggest that the normal version of SCGB1D2 could be leveraged as a treatment for Lyme disease, the most common tickborne infection in the United States and Europe. The protein might also be used to prevent infection, Tal says.

It's unclear how the protein might interact with bacteria once a tick digs in for a bite, says medical entomologist Adela Oliva Chávez of the University of Wisconsin–Madison. Tal and colleagues exposed mice to *B. burgdorferi* via needle injections, bypassing any tactics a tick might have to make SCGB1D2 less effective. Though there are still many unknowns, "I'm excited, with caution," Oliva Chávez says. ■

NEUROSCIENCE

Fruit flies strut their stuff on treadmills

The workouts may help reveal how the brain controls movement

BY LAURA SANDERS

The runner on the treadmill wasn't a typical gym rat. For one thing, he would sprint to the front of the machine and then ride it to the back. For another, he had six legs.

The exerciser was a fruit fly, and he belonged to a cohort that ran on a tiny treadmill surrounded by high-speed cameras. Results from the workouts, posted February 24 at bioRxiv.org, have already revealed insights about how bodies move.

"This opens a great opportunity to examine how the central nervous system of the fly controls different aspects of walking," says systems neuroscientist Eugenia Chiappe of the Champalimaud Foundation in Lisbon, Portugal. Understanding how the brain pulls this off is important, she says, because the ability to control movement is crucial for survival.

Made of belts, pulleys and motors, the treadmill measured about 9 millimeters in length — just over four times as long as the fruit flies (*Drosophila melanogaster*). Researchers put the machine in a glass chamber coated with slippery Rain-X to keep flies from wall-walking and they clipped flies' wings to prevent flight. When the treadmill was on, the only floor available was moving. Based on where the flies' legs hit the ground, the team determined that the insects were moving naturally.

Flies tended to run to the front of the treadmill and then ride it back to the end. When their abdomens grazed the back wall of the chamber, the startled flies would sprint forward again. And they easily ran 50 millimeters per second, the fastest ground speed ever reported for *Drosophila*, says neural engineer Brandon Pratt of the University of Washington in Seattle. As the flies increased speed, they rose up on their tiptoes. But one thing they wouldn't do: Run backward.

Pratt and colleagues modified the treadmill to have two side-by-side belts, which forced the flies to move each side of their body at a different speed. The middle legs compensated by adjusting step distances, keeping flies moving straight ahead.

Chiappe notes that the treadmill doesn't let scientists record neural activity while the flies are moving, which would be valuable data. Other systems do, but flies don't move as naturally on them.

Besides providing scientific insights, the tests sparked friendly competition, Pratt says. "We were like, 'Can we find the most athletic fly?'" he says. "We even did a side project where we did endurance training in flies. It got a little ridiculous." ■

RBKOMAR/MOMENT/GETTY IMAGES

PSYCHOLOGY

World happiness rankings fall short

Poll overlooks how different cultures think about well-being

BY SUJATA GUPTA

For the seventh year running, the Finns have taken the top spot as the world's happiest people. That's according to the 2024 World Happiness Report, released March 20. Per usual, the other Nordic countries — Denmark, Iceland, Sweden and Norway — are all in the top 10 of 143 countries surveyed.

Over the last decade or so, a consortium of international organizations has issued yearly happiness rankings, along with detailed reports on well-being. The rankings are derived from the Gallup World Poll and provide countries with a way to measure national success — and develop policies that enhance well-being — beyond economic measures like gross domestic product, which encourage more economic growth than the planet can handle.

There may be benefits to evaluating non-economic markers of a country's success, but not all researchers agree that happiness looks the same around the world. Culture can influence how people in different countries respond to surveys of happiness, says macropsychologist Kuba Krys of the Polish Academy of Sciences in Warsaw. "We should be careful … making big claims based on such comparisons."

The rankings may suffer from a Western bias, Krys says, because they depend on a concept of happiness common in WEIRD societies — Western, educated, industrialized, rich and democratic.

The happiness report rankings rely on responses to one question: "Imagine a ladder with steps numbered from 0 at the bottom to 10 at the top. The top of the ladder represents the best possible life for you, and the bottom of the ladder represents the worst possible life for you. On which step of the ladder would you say you personally feel you stand at this time?"

Finnish respondents, on average, stand just below the eighth rung. U.S. respondents stand about one rung lower, a score that lands them in 23rd place on the list. People in Afghanistan, meanwhile, have not made it to the second rung. But can these scores be meaningfully compared across countries?

In 2018 and 2019, researchers asked 200 people in Tanzania, a low-ranking country, how they selected their rung. Just over a third, most of them with limited formal education, did not understand the question. One woman vacillated between a score of 0 and 10 while another raised her score from 6 to 8 believing it would help her financially, the team reported in 2022 in the *International Journal of Wellbeing*.

Moreover, many people, especially outside the West, fear that admitting to a high level of happiness may cause something bad to happen, which can depress their scores on a standardized survey, says Mohsen Joshanloo, a personality and cultural psychologist at Keimyung University in Daegu, South Korea.

Krys and colleagues' work has shown that not everyone wants maximum happiness. They surveyed almost 13,000 people in 49 countries to evaluate how much an "ideal or perfect person" would agree with various statements reflecting happiness. Responses ranged from 1 for "doesn't describe him/her at all" to 9 for "describes him/her exactly."

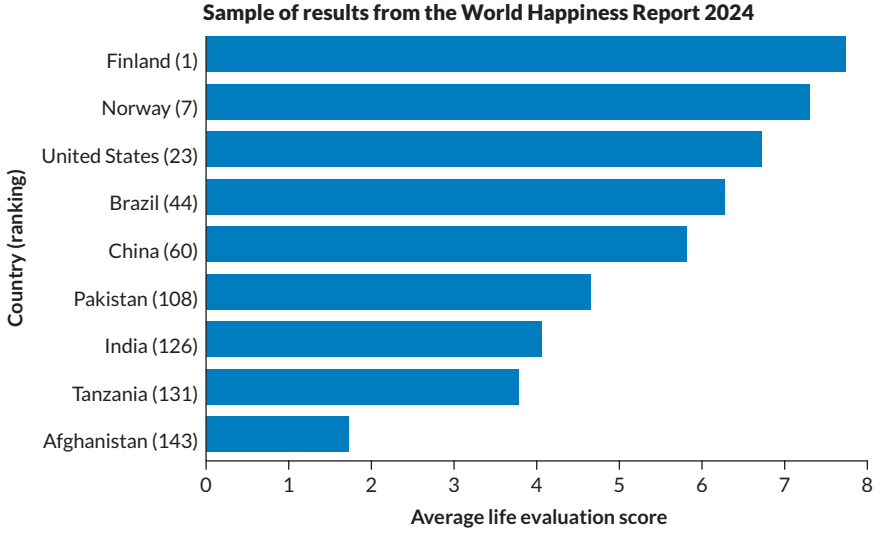
Ideal happiness varied widely by country. In Germany and Iceland, about 85 percent of participants equated ideal happiness with average scores of 7 and above. But in Bhutan, Ghana, Nigeria, Pakistan and Japan, 70 percent or more selected a lower ideal, the team reported in February in *Perspectives on Psychological Science*.

In the future, researchers could adjust the happiness report rankings to reflect a culture's ideal level of happiness. But a singular focus on happiness is itself a problem, Krys says. Non-Westerners often place greater emphasis on other aspects of a good life, such as harmony or meaning, research shows. Sometimes, scores in one category conflict with scores in another.

Scientists who work on the happiness report are studying other measures of well-being, says report editor Lara Aknin, a social psychologist at Simon Fraser University in Burnaby, Canada. In 2022, they zoomed in on questions related to balance and harmony in the 2020 Gallup World Poll. People worldwide value those concepts, and with few exceptions, tend to prefer a calm life, the team found.

Krys and others would like to see a variety of well-being rankings in the report. "Happiness is not the universal, sole … aim of people's lives," Krys says. ■

Ranking happiness For the seventh year in a row, Nordic countries scored near the top of the world happiness rankings, some of which are shown below. Non-Western countries, such as India and Tanzania, placed lower. But many researchers argue that the method for generating the rankings has a Western bias. SOURCE: WORLD HAPPINESS REPORT 2024



B. PRICE

ARTIFICIAL INTELLIGENCE

An AI learned to sway human behavior

New method could teach bots to collaborate — or manipulate

BY MATTHEW HUTSON

If you've ever cooked a complex meal with someone, you know the level of coordination required. Someone dices this, someone else sautés that, as you dance around holding knives and hot pans. Meanwhile, you might wordlessly nudge each other, placing ingredients or implements within the other's reach when you'd like something done.

How might a robot handle this type of interaction?

In December at the Neural Information Processing Systems conference in New Orleans, researchers presented some clues. In a simple virtual kitchen, artificial intelligence learned how to influence a human collaborator just by watching humans work together.

In the future, humans will increasingly collaborate with AI, both online and in the physical world. And sometimes we'll want an AI to silently guide our choices and strategies, like a good teammate who knows our weaknesses. "The paper addresses a crucial and pertinent problem," how AI can learn to influence people, says Stefanos Nikolaidis, director of the Interactive and Collaborative Autonomous Robotic Systems lab at the University of Southern California in Los Angeles who was not involved in the research.

The new work introduces a way for AI to learn to collaborate with humans, without even practicing with us. It could help improve human-AI interactions, Nikolaidis says, or it could help AI take advantage of us — whether humans have programmed it to do so, or, someday, it programs itself.

Learning by watching

There are a few ways researchers have already trained AI to influence people. Many approaches involve what's called reinforcement learning, in which an AI interacts with an environment — which can include other AIs or humans — and is rewarded for making sequences of decisions that lead to desired outcomes. Google DeepMind's program AlphaGo, for example, learned the board game Go using reinforcement learning.

But training a clueless AI from scratch to interact with people through sheer trial and error can waste a lot of human hours and can even present risks if there are, say, knives involved (as there might be in a real kitchen). Another option is to train one AI to model human behavior, then use that as a tireless human substitute for another AI to learn to interact with. Researchers have used this method in a simple game that involved entrusting a partner with money. But realistically replicating human behavior in more complex scenarios can be difficult.

In the new study, researchers at the University of California, Berkeley used offline reinforcement learning. It's a method for developing strategies by analyzing documented behavior rather than through real-time interaction. Previously, offline reinforcement learning had been used mostly to help virtual robots move or to help AIs solve mazes, but here it was applied to the tricky problem of influencing human collaborators. Instead of learning by interacting with people, this AI learned by watching human interactions.

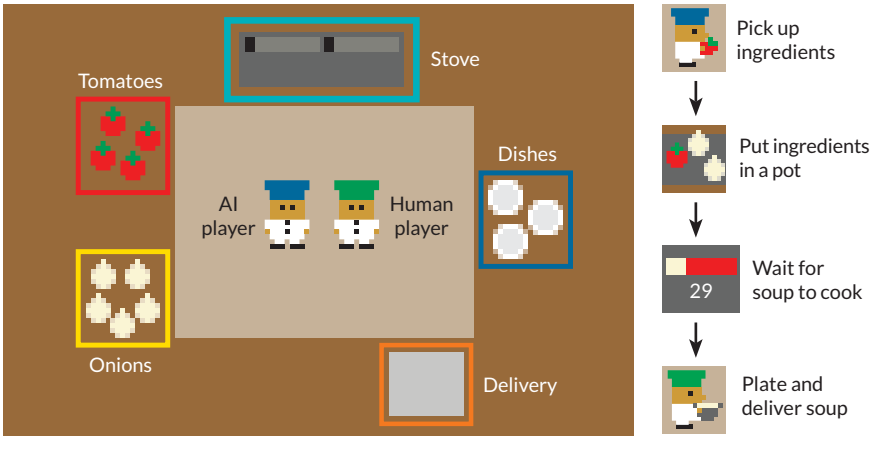
Humans already have a modicum of competence at collaboration. So the amount of data needed to demonstrate competent collaboration when two people are working together is not as much as would be needed if one person were interacting with an AI that had never interacted with anyone before.

Making soup

The UC Berkeley team used a simplified version of a video game called *Overcooked*, in which two chefs divvy up tasks to prepare and serve meals, in this case soup, which earns them points. It's a 2-D world, seen from above, filled with onions, tomatoes, dishes and a stove with pots. At each time step, each virtual chef can stand still, interact with whatever is in front of it, or move up, down, left or right.

The researchers first collected data from pairs of people playing the game. Then they trained AIs using offline reinforcement learning or one of three other methods for comparison. (The AIs in all methods were built on a neural network, a software architecture intended to roughly mimic how the brain works.) In one method, the AI just imitated the humans. In another, it imitated the best human performances. The third method ignored the human data and had AIs practice with each other. And the fourth was the offline reinforcement learning,

Yes, chef In a simple version of a video game called *Overcooked*, an AI chef and a human chef collaborate to make soup containing tomatoes and/or onions. But only the AI chef knows that the duo will receive a bonus if the human chef serves the soup once it's ready. Through a new method that trains AIs how to influence human behavior, the AI chef figured out that if it places a dish next to the stove, the human chef will use the dish to deliver the soup.



J. HONG *ET AL*/NEURAL INFORMATION PROCESSING SYSTEMS 2023, ADAPTED BY B. PRICE

Watch a video of an AI nudging a human in a game at **bit.ly/SN_Overcooked**

in which the AI pieced together the best bits of what it saw, aiming to perform better than the behavior it observed. With this method, the AI uses a kind of counterfactual reasoning: It predicts what score it would have gotten if it had followed different paths in certain situations, then adapts.

The AIs played two versions of the game. In the "human-deliver" version, the team earned double points if the soup was delivered by the human partner. In the "tomato-bonus" version, soup with tomato and no onion earned double points. After the training, the chefbots played with real people. The scoring system was different during training and evaluation than when the initial human data were collected, so the AIs had to extract general principles to score higher. Crucially, during evaluation, humans didn't know these rules, such as no onion, so the AIs had to nudge them.

On the human-deliver game, training with offline reinforcement learning led to an average score of 220, about 50 percent more points than comparison methods. On the tomato-bonus game, it led to an average score of 165, or about double the points.

To support the hypothesis that the AI had learned to influence people, the researchers point to the fact that when the bot wanted the human to deliver the soup, it would place a dish on the counter near the human. In the human-human data that the AI trained on, the researchers found no instances of one person passing a plate to another in this fashion. But there were events where someone put down a dish and ones where someone picked up a dish, and the AI might have seen value in stitching these acts together.

Nudging human behavior

The researchers also developed a method for the AI to infer and then influence humans' underlying strategies in cooking steps, not just their immediate actions. In real life, if you know that your cooking partner is slow to peel carrots, you might jump on that role each time until your partner stops going for the carrots. A modification to the neural network to consider not only the current game state but also a history of the partner's actions would give a clue as to what the partner's current strategy is.

Again, the team collected human-human data and then trained AIs using this offline reinforcement learning network architecture or the previous one. When tested with human partners, inferring the partner's strategy improved scores by roughly 50 percent on average. In the tomato-bonus game, for example, the bot learned to repeatedly block the onions until people eventually left them alone. That the AI worked so well with humans was surprising, says UC Berkeley computer scientist Joey Hong.

> "We, as a field, have yet to integrate ways for a person to communicate to a system what types of influence they are OK with."
>
> **MICAH CARROLL**

Avoiding the use of a human model is great, says Rohan Paleja, a computer scientist at MIT Lincoln Laboratory in Lexington, Mass. "It makes this approach applicable to a lot of real-world problems that do not currently have accurate simulated humans." He also says the system is efficient; it achieved its abilities after watching only 20 human-human games though each was 1,200 steps long.

Nikolaidis sees potential for the method to enhance AI-human collaboration. But he wishes that the authors had better documented the observed behaviors in the training data and exactly how the AI trained with the new method affected people's behaviors to improve scores.

For better or worse

In the future, we may work with AI partners in kitchens, warehouses, operating rooms, battlefields and digital domains like writing, research and travel planning. (We already use AI tools for some of these tasks.) "This type of approach could be helpful in supporting people to reach their goals when they don't know the best way to do this," says Emma Brunskill, a computer scientist at Stanford University. She proposes that an AI could observe data from fitness apps and learn to better nudge people to meet New Year's exercise resolutions through notifications (SN: 3/18/17, *p.* 18). An AI trained by the method might also learn to get people to increase charitable donations, Hong says.

On the other hand, AI influence has a darker side. "Online recommender systems can, for example, try to have us buy more, or watch more TV," Brunskill says, "not just for this moment, but also to shape us into being people who buy more or watch more."

Previous work, which was not about human-AI collaboration, has shown how reinforcement learning can help recommender systems manipulate users' preferences to make them more predictable and satisfiable, even if people didn't want their preferences shifted.

And even if AI means to help, it may do so in ways we don't like, says Micah Carroll, a UC Berkeley computer scientist who works with one of the study coauthors. For instance, the strategy of blocking another chef's path could be seen as a form of coercion.

"We, as a field, have yet to integrate ways for a person to communicate to a system what types of influence they are OK with," Carroll says. "For example, 'I'm OK with an AI trying to argue for a specific strategy, but not forcing me to do it if I don't want to.'"

Hong is currently looking to use his approach to improve chatbots (SN: 1/27/24, *p.* 18). The large language models behind interfaces such as ChatGPT typically aren't trained to carry out multiturn conversations. "A lot of times when you ask a GPT to do something, it gives you a best guess of what it thinks you want," he says. "It won't ask for clarification to understand your true intent and make its answers more personalized."

Learning to influence and help people in a conversation may be a more realistic near-term application. "*Overcooked*," Hong says, with its two dimensions and limited menu, "is not really going to help us make better chefs." ■

Taking Control

Geneticist Krystal Tsosie advocates for Indigenous data sovereignty

By Joseph Lee

Krystal Tsosie leads the Tsosie Lab for Indigenous Genomic Data Equity and Justice at Arizona State University.

KATHLEEN DREIER

Krystal Tsosie grew up playing in the wide expanse of the Navajo Nation, scrambling up sandstone rocks and hiking in canyons in northern Arizona. But after her father started working as a power plant operator at the Phoenix Indian Medical Center, the family moved south to the city. "That upbringing in a lower socioeconomic household in West Phoenix really made me think about what it meant to be a good advocate for my people and my community," says Tsosie, who like other Navajo people refers to herself as Diné. Today, she's a geneticist-bioethicist at Arizona State University in Tempe. The challenges of urban life for Tsosie's family and others, plus the distance from the Navajo Nation, helped spark the deep sense of community responsibility that has become the foundation of her work.

Tsosie was interested in science from an early age, volunteering at the Phoenix Indian Medical Center in high school with the hopes of eventually becoming a doctor. She remembers seeing posters at the Indian Health Service clinic in Phoenix warning against the dangers of rodents and dust. The posters were put up in response to cases of hantavirus pulmonary syndrome, or HPS, in the Four Corners area in 1993. Though the disease had not been identified by Western science until that outbreak, it had long been known within the Navajo tradition. Learning how Navajo oral traditions helped researchers understand HPS made Tsosie want to work in a laboratory studying diseases, instead of becoming a practicing physician.

Tsosie settled on cancer biology and research after college, in part because of the health and environmental impacts of decades of uranium mining on the Navajo Nation. But after leaving Arizona for the first time after college, Tsosie was confronted with the profit-driven realities and what she calls the entrenched, systemic racism of the biomedical space. She saw a lack of Indigenous representation and disparities that prevented Indigenous communities from accessing the best health care. Tsosie

began asking herself whether her projects would be affordable and accessible to her community back home. "I didn't like the answer," she says.

The need for Indigenous geneticists

So Tsosie returned to Arizona to work on a master's degree in bioethics with the intention of going to law school. But the more she learned about how much genetic research relies on big data and how those data are shared and used, the more Tsosie realized there was a huge need for Indigenous geneticists.

Around the world, scientific use of Indigenous genetic data has led to repeated violations of rights and sovereignty. For example, beginning in 1990, Havasupai Tribal members gave DNA samples to researchers from Arizona State Unviersity, hoping to understand more about diabetes in the community. Researchers eventually used the Havasupai DNA in a range of studies, including for research on schizophrenia and alcoholism, which the Havasupai say they had not been properly informed about or consented to. In 2010, the Arizona Board of Regents settled with Tribal members for $700,000 and the return of the DNA samples, among other reparations.

> "We have an unfortunate colonial, extractive way of coming into communities and taking samples, taking DNA."
>
> KRYSTAL TSOSIE

The Havasupai case is perhaps the most high-profile example in a long history of Western science exploiting Indigenous DNA. "We have an unfortunate colonial, extractive way of coming into communities and taking samples, taking DNA, taking data, and just not engaging in equitable research partnerships," Tsosie says.

This history prompted the Navajo Nation in 2002 to place a "moratorium on genetic research studies conducted within the jurisdiction of the Navajo Nation." It has also, along with the growth of genomics, convinced Tsosie that Indigenous geneticists must play a big role in protecting Indigenous data and empowering Indigenous peoples to manage, study and benefit from their own data. "It's the right of Indigenous peoples to exercise authority, agency, autonomy, and self-direct and self-govern decisions about our own data," she says.

Tsosie was determined to become one of those Indigenous geneticists, and in 2016, she began dissertation research at Vanderbilt University in Nashville. Around that time, she met Keolu Fox and Joseph Yracheta, two other Indigenous scientists interested in genetics. Fox, who is Kānaka Maoli and a geneticist at the University of California, San Diego, believes Tsosie and others prioritizing Indigenous health and rights represent a paradigm shift in genetics. "Minority health is not an afterthought to someone like Krystal; it is the primary goal," Fox says. "We have not been allowed to operate large laboratories in major influential academic institutions until now. And that's why it's different."

In 2018, Tsosie, Yracheta and colleagues, with key support from Fox, founded the Native BioData Consortium, an Indigenous-led nonprofit research institute that brings Indigenous scholars, experts and scientists together. The consortium's biorepository, which Tsosie believes is the first repository of Indigenous genomic data in North America, is located on the sovereign land of the Cheyenne River Sioux Tribe in South Dakota. The consortium supports various research, data and digital capacity building projects for Indigenous peoples and communities. These projects include researching soil health and the microbiome and creating a Tribal public health surveillance program for COVID-19 that has Clinical Laboratory Improvement Amendments certification, a federal regulatory standard, as well as hosting workshops for Indigenous researchers.

The work may be even more essential given current genomics trends: With Indigenous nations in the United States restricting access to their DNA, researchers and corporations are seeking DNA from Indigenous peoples in Latin America.

UNSUNG CHARACTERS

This article is part of a *Science News* series highlighting people of science — past and present — who we believe should be better known. Watch for more of these stories, and send your ideas to editors@sciencenews.org

A young Krystal Tsosie is shown on the Navajo Nation.

COURTESY OF ELLOISE TSOSIE

"We are now in the second era of discovery or the second era of colonization," says Yracheta, who is P'urhépecha from Mexico, director of the consortium and a doctor of public health candidate in environmental health at Johns Hopkins University. "Lots of Indigenous spaces are small and shrinking and we're trying to prevent that happening by asserting Indigenous data sovereignty not only over humans and biomedical data, but all data."

Tsosie, Yracheta says, consistently works to bring Indigenous values and accountability to the consortium's work and has an invaluable combination of skills. "She has a lot of really hard-core scientific background and now she's mixing it with bioethics, law and policy and machine learning and artificial intelligence," he says. "We make a really good team."

Krystal Tsosie (below) and students Jonathan Kim and Kai-Se Toledo review art created by students in a biology and society course at Arizona State University. Some of the art deals with issues of data sovereignty (right).

BOTH: KATHLEEN DREIER

Training the next generation

Today, Tsosie leads the Tsosie Lab for Indigenous Genomic Data Equity and Justice at ASU. One lab project involves working with Tribal partners in the Phoenix area to create a multiethnic cohort for genomic and nongenomic data. The data, which will include social, structural, cultural and traditional factors, could provide a more complex picture of health disparities and what causes them, as well as a more nuanced understanding of Indigenous identity and health.

In addition to her own research, Tsosie spends time teaching, mentoring, traveling to speak about the importance of data sovereignty, and serving as a consultant for tribes who want to develop their own data policies. "We're not just talking about doing research with communities," she says. "We're also helping to cocreate legal policies and resolutions and laws to help Tribal nations and Indigenous peoples protect their data and rights to their data."

At ASU, Tsosie says she is in the position to push back against some of the prevailing trends in Indigenous genomics, including the tendency to lump Indigenous people together, regardless of environmental, cultural and political factors. "This is an opportunity for my lab to really explore the fact that being Indigenous is not always a biological category. It's one that's mediated by culture, and also sociopolitical factors that have sometimes been imposed on us," Tsosie says.

And while Tsosie's goals are ambitious, she is equally committed to uplifting the next generation of Indigenous scientists. "Krystal puts in so much time and energy into ensuring that the next generation of students are getting ecosystems where they feel safe and protected to learn about new disciplines," Fox says. "It's just so special."

To Tsosie, empowering Indigenous communities to make decisions about their data and supporting Indigenous students are part of the same mission. "It just makes me happy to think about several academic generations in the future, how many of us will be occupying this colonial space that we call academia," she says. "Then we can really start shifting this power imbalance towards something that is truly enriching and powerful for our peoples and our communities." ■

Explore more

- Learn about the Native BioData Consortium at nativebio.org

Joseph Lee is an Aquinnah Wampanoag writer based in New York City.

After lightning strikes sparked wildfires in California's Six Rivers National Forest last summer (shown), firefighters allowed some flames to grow and ignited more to clear out vegetation that could fuel even more dangerous fires in the future.

W. HARLING

Fighting fire with fire

A new approach combines local knowledge and AI to manage wildfires. Sometimes that means letting them burn

By Nikk Ogasa

On June 4, 2021, amid flowering saguaros and prickly pear cacti, a wildfire bloomed in the Sonoran Desert in central Arizona. Its nascent flames spread on nonnative grasses desiccated by a long, severe drought. A nearby weather station recorded a temperature of 36° Celsius (97° Fahrenheit). It was so dry that the blades of firefighters' bulldozers — used to clear brush — sparked small flames as the heavy vehicles dragged on rocks.

Fire ecologist Mary Lata of the U.S. Forest Service first heard about the fire over the radio while conducting fieldwork off to the north, in the Tonto National Forest. "I remember hearing them talking," she says, "and little by little realizing they weren't going to catch this one."

By June 7, winds had blown the wildfire east-northeast into the Pinal Mountains, in the Tonto's southern reaches. The flames ascended rapidly, overcoming rock cliffs — defying the expectations of veteran firefighters, Lata says — and sweeping through vast, unbroken stretches of chaparral. When the fire reached the highest elevations, crowned by pine forests, it swallowed those too.

The Telegraph Fire, as it's now called, grew so intense that it began to create its own wind, its rising heat generating a convective force that sucked in air from the sides, Lata says. "Of all the fires I've worked on, Telegraph was the nastiest."

On the fifth day, the fire neared the city of Globe. By then, it had already consumed an expanse that exceeded the area of Globe five times over. The blaze would go down as one of the largest conflagrations in Arizona history, engulfing some 700 square kilometers of land — equal to about half the area of Phoenix. But the fire would not swallow Globe.

Instead, on a ridge just outside the city, the Telegraph Fire encountered a bulwark, the vestiges of a bygone blaze.

Four years earlier, lightning had sparked the Pinal Fire in this location, albeit under milder conditions. Recognizing the need to clear out vegetation that might feed future blazes, fire crews allowed the blaze to consume litter, seedlings and other brush near to the ground. Crews even ignited flames of their own, expanding the fire's breadth.

Arriving at the Pinal's leftovers, the Telegraph Fire "went from a running canopy fire, where it was killing about 60 to 70 percent of the trees that it had encountered, to a creeping ground fire, where it was killing about 1 percent of the trees encountered," says Kit O'Connor, an ecologist at the Forest Service in Missoula, Mont. Eventually, the fire halted about a kilometer away from a neighborhood in Globe's outskirts.

Had it not been for the Pinal Fire, the Telegraph Fire would have burned into town, Lata says. "There's nothing we could have done to stop it."

The decision to let the Pinal Fire burn had been guided by a new blueprint for wildfire management, known as potential operational delineations. PODs section the landscape into zones within which fires can feasibly be contained. The boundaries are determined before the fire season starts by a mixture of artificial intelligence and local knowledge. A POD network can help land managers identify opportunities to harness wildfires that ignite under manageable conditions. The hope is that if subsequent fires erupt amid extreme conditions, there will be less brush available to fuel their fury.

"If you have a fire that's rushing towards homes, and there is no burned-out area or fuels cleared around those homes, they're basically guaranteed to be lost," says O'Connor, who has helped construct PODs throughout the West.

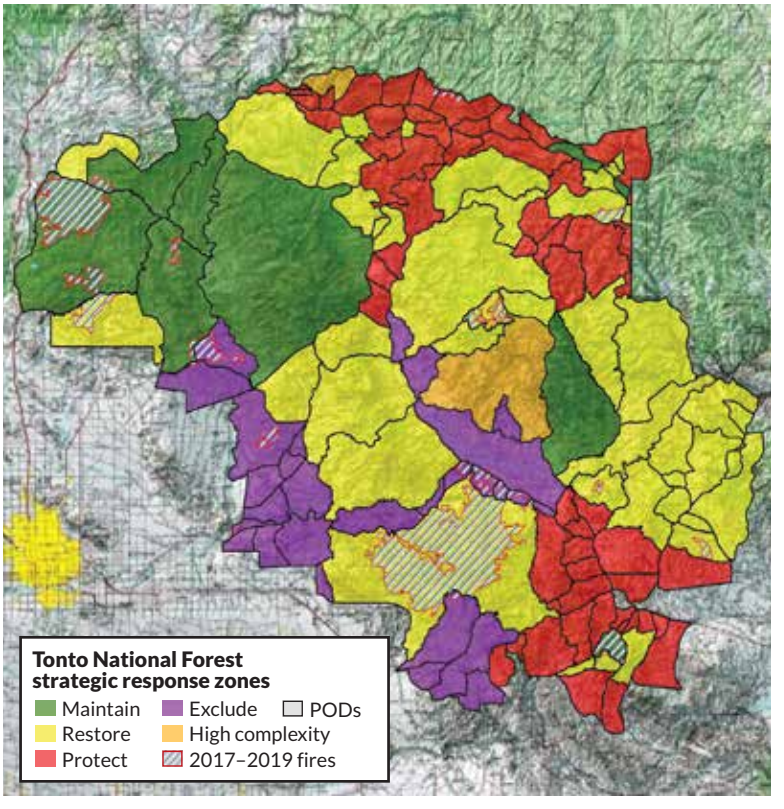
Today, POD networks sprawl across the West, from California to Washington and as far east as Minnesota. That coverage includes some 70 national forests, as well as state and private lands.

But as these wildfire blueprints spread, they face challenges. Keeping them updated to reflect the changing nature of the landscape is a crucial but difficult endeavor. And whether they will protect the interests of the Indigenous people who have managed the landscape for centuries remains to be seen.

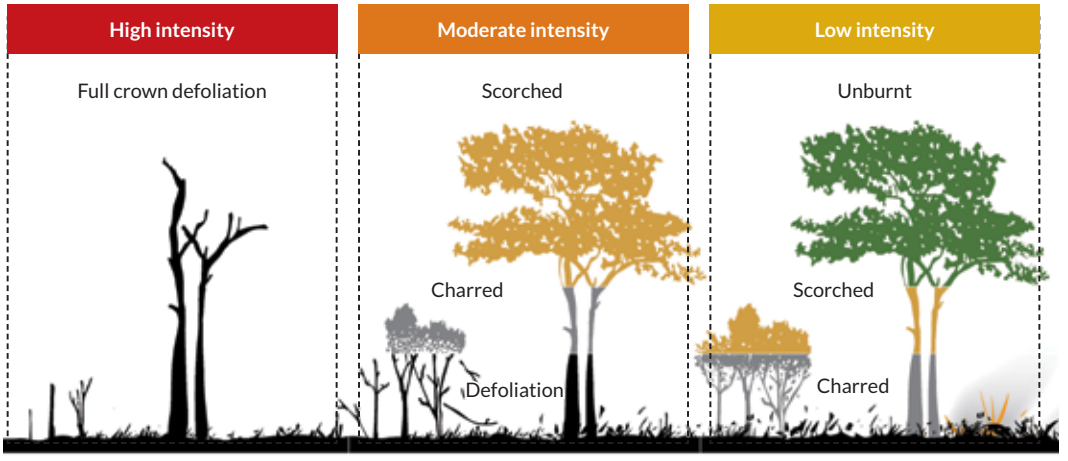
But the need for a new strategy is massive.

Climate change and decades of misguided fire management have steadily stoked wildfires in the West. Compared with four decades ago, the average area burned by western blazes each year has more than doubled. During the region's record-breaking 2020 wildfire season, thousands of fires burned an area larger than the state of Maryland. These

POD network The Tonto National Forest in Arizona is divided into PODs, zones in which wildfires can be contained. Color-coding helps plan responses: In green "maintain" zones, fires may be beneficial. In red "protect" zones, fires put people at high risk and should be suppressed. In purple "exclude" zones, fires should be put out to protect the Sonoran Desert ecosystem. In yellow "restore" zones, fires may be safe in certain conditions. If properly managed, "high complexity" orange zones could become restore zones.



K. O'CONNOR



Fire scale A variety of factors influence the intensity of a wildfire, including weather conditions and the vegetation present. A low-intensity fire stays close to the ground and mostly clears out low-lying vegetation and spares taller trees. A high-intensity fire, however, can climb into tree canopies and cause the complete loss of leaves and needles. But a lack of low-lying vegetation can slow these destructive blazes or even prevent them.

blazes are now burning more than twice as many homes and buildings as at the beginning of this century—from 2010 to 2020, fires destroyed more than three structures for each 10 square kilometers burned. And scientists predict that more land, and more homes, will burn in the future.

But working with manageable wildfires that emerge in ideal locations under favorable weather conditions to clear away dense vegetation could help reduce the risk that bigger blazes pose to homes and people across the western United States. "We can't make fire go away," O'Connor says. But "there's potential for huge benefits" in finding opportunities to use it.

Collaborating to change

On December 4 of last year, there was no smoke discernible in the sky above Monterey, Calif. The worst months of the state's fire season—July to November—had passed. But as seasons go, so do they return. So on this day in Monterey, a crowd of firefighters, conservationists and researchers had gathered in anticipation of the fires yet to come.

"We're sort of stuck between two paradigms," Christopher Dunn told the group. Projected behind him were two images. On the left, a painting from 1905 depicts a member of the Blackfeet Tribe crouched on a prairie, setting fire to the grass with a flaming torch. On the right, a staged photo from 1955 shows a fire brigade of jeeps and a helicopter heading toward a smoking fire in the distance. "We need both of these," said Dunn, a forestry researcher at Oregon State University in Corvallis.

In 1910, just five years after the birth of the Forest Service, the Big Blowup—some 1,700 wildfires in Montana, Idaho and Washington—burned over 12,000 square kilometers in just a couple days. As a result, Congress passed the 1911 Weeks Act, which effectively outlawed traditional uses of fire by Indigenous people. They had used fire for a trove of benefits, from corralling bison to clearing brushy areas for crops. In 1935, the Forest Service enacted the "10 a.m. policy," in which every reported fire should be suppressed by the 10th hour of the next day.

Fast-forward to today, and about 98 percent of U.S. wildfires are suppressed before reaching 1.2 square kilometers. Suppressing most wildfires has allowed thick, continuous beds of vegetation to grow. Under extreme conditions, such fuel loads can nourish huge blazes like the Telegraph Fire. A landscape with frequent fire, on the other hand, tends to develop a patchwork of areas that burned at different points in the past, with vegetation at various stages of regrowth. Such pyrodiverse landscapes, with their rich mix of habitat types, can boost an area's biodiversity, scientists suspect. What's more, recently burned patches contain diminished fuel stocks, which can hinder the growth of wildfires even under extreme conditions, like the Pinal Fire scar did.

"We want more fire," Dunn said. He was speaking to a crowd focused on developing PODs for lands in and adjacent to California's Los Padres National Forest, along the state's mountainous Central Coast between Monterey and Ventura.

First introduced in a 2016 paper based on work led by the Forest Service in California's Sierra Nevada, PODs are, at their simplest, polygons drawn on a map. Their boundaries typically follow features from where fire can be safely and effectively contained, like ridgetops, roads or rivers. These boundaries can also inform where prescribed burning, selective logging or other actions could be taken to reduce vegetation and minimize fire risk.

POD networks resemble geometric cobwebs, typically strung together during the fire off-season in workshops attended by land managers, tribal members, fire crews, researchers and other

local stakeholders. The workshops allow for the proactive sharing of knowledge that might otherwise remain siloed, O'Connor says. "It really helps to involve all the different players in the long-term management of a piece of ground."

For the second part of the workshop, Dunn and his colleagues spread large topographic maps across tables in two rooms, showing various sections of Los Padres National Forest and proximal lands.

Some of the maps were shaded in where wildfires had burned recently or where measures to reduce burnable vegetation had occurred. Other maps were colored over by a machine learning algorithm that draws from data on topography, fuel characteristics, road networks and historical fires to predict and map the most effective locations for stopping a blaze. This "potential control line" model doesn't know the land as well as local land managers, but it can help them reach a consensus, O'Connor says.

There were also maps colored by another algorithm, called the suppression difficulty index model. It tells "you how difficult it would be to move people and equipment to any part of the landscape," O'Connor says. In other words, where it's hardest to fight a fire from.

Dunn tasked workshop participants with drawing PODs on these maps, using the shaded and colored areas as guides for where to sketch boundary lines. With sharpies in hand, attendants began drawing dark lines on the maps, sometimes following features accentuated by the models, other times diverging. Discussions filled the air.

"The only way to keep going this way is a really gnarly ridge."

"We used this section on the Dolan Fire. It was good."

"That road doesn't go all the way through anymore."

"It does."

In some national forests, PODs are augmented with another tool, the Quantitative Wildfire Risk Assessment, or QWRA. These assessments chart where a fire may be most damaging, taking into consideration the locations of homes, endangered species habitats, timber resources and other assets.

When dressed with QWRAs, skeletal POD networks metamorphose into vibrant mosaics, mostly in the colors of a stoplight. When PODs are colored green, they signal areas that could benefit ecologically from fire and where a fire is unlikely to damage resources. Here, letting wildfires burn may be a go. Alternatively, a red POD contains a lot of resources at risk of being lost in a fire. Any emerging fires should probably be stopped. Some PODs fall into an in-between yellow category: The POD could benefit from fire, but only under the right conditions.

With these ratings in hand, land managers can strategize how best to handle fire. The 2017 Pinal Fire emerged in a yellow POD, which firefighters let burn.

After the Monterey workshop, the hand-drawn lines were digitized and made publicly available for viewing on the Risk Management Assistance Dashboard, an online platform developed by the Forest Service in 2020 where users can follow up with comments and suggest alterations.

PODs can also be updated in follow-up workshops in subsequent years. But gathering people year after year is easier said than done. "For [PODs] to be useful, they have to be updated," says forest and wildlife researcher Michelle Greiner of Colorado State University in Fort Collins. The landscape changes over time. But keeping PODs up-to-date, or even in the awareness of land managers and fire crews, "takes a lot of time and a lot of capacity," she says, "and I think it kind of remains to be seen if that's something that's going to be sustained."

One step the Forest Service has taken is to hire regional analysts responsible for keeping POD networks updated and relevant, O'Connor says. "We want to make sure that we're expanding on and growing out of what's already been done," he says. "We don't want these tools to be forgotten."

Cultural conflicts

Drive about six hours north of Monterey, and you'll find yourself in the Klamath Mountains, which straddle the California-Oregon border. Indigenous people

The 2021 Telegraph Fire (shown) became one of the worst wildfires in Arizona history. But as it approached the city of Globe, the fire slowed where a previous wildfire had burned away litter, seedlings and other brush near the ground.

MARK HENLE, POOL/AP PHOTO

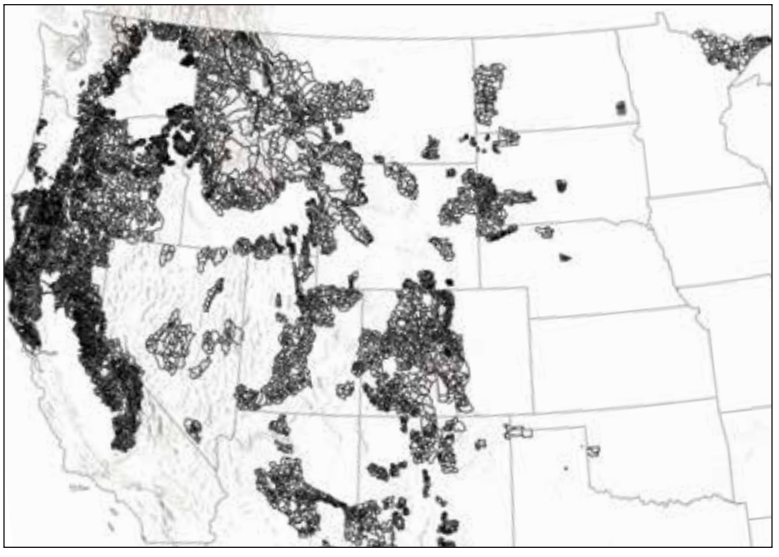
from the Karuk, Yurok, Hoopa Valley and other tribes have lived in this region for thousands of years.

Indigenous people's setting of frequent, low-intensity fires yielded many ecological benefits, such as promoting elk habitat and restoring nutrients to soils. In fact, Karuk and Yurok burning practices, along with naturally ignited fire activity, promoted the stability of a forest in the western Klamath Mountains for a millennium, a 2022 study showed. But suppressive fire policies over the last century have drastically changed the land.

"If you could look back 150 years ago, you would see a landscape that was shaped by fires," says Nolan Colegrove, a district ranger for the Forest Service and a member of the Hoopa Tribe. In the Klamath Mountains where Colegrove works, lofty Douglas fir trees crowd many patches of land once occupied by grasses or shrubs.

A unique POD network has taken root here. Its development has been led by the North Coast Resource Partnership, or NCRP, an organization helmed by elected officials from the region's tribes and counties. Across 49,000 square kilometers of northwestern California, the partnership works on projects that benefit local communities and watersheds. Usually, the Forest Service leads the development of PODs, Dunn says. Here, the tribes and counties took up the work. This ensures that everyone in the community is involved, says Will Harling, director of the Mid Klamath Watershed Council, a nonprofit that collaborates on the POD network. Harling notes that when the Forest Service develops a POD network, the agency doesn't always seek the support or buy-in of everyone in the community. "Everybody that has skin in the game needs to be around that table, or else it doesn't work," he says.

Spread like wildfire
POD networks (outlined in black) extend across some 70 national forests and on state and private lands in the United States. Some recently drafted POD networks, such as the one for Los Padres National Forest, are not shown.



U.S. FOREST SERVICE

Invitees to NCRP's POD workshops included representatives from local tribes, county governments, the Forest Service, industrial timber, municipal fire departments, homeowners associations, and the California Department of Forestry and Fire Protection. Bringing everyone together was eye-opening, revealing how past efforts to reduce wildfire risk had failed, Harling says.

But the POD approach has sparked disputes. For instance, the data in PODs are publicly available, but much of the ecological and cultural knowledge that tribes possess may be too sensitive for public disclosure. In POD workshops, Indigenous people may help delineate POD boundaries on their historic lands while withholding where along those lines tribal resources exist. Later on, those lines may be treated by fire crews in unexpectedly destructive ways.

"A lot of our [culturally] sensitive areas are on ridges and mountaintops and in these places where [control] lines and other suppression tactics are often constructed," says Vikki Preston, a member of and cultural resources technician for the Karuk Tribe. When fire crews unaffiliated with tribes come in to clear brush and thin the forest, they can damage or destroy ceremonial trails, archaeological sites and other important tribal resources.

"I've seen dozers go through a mushroom patch that people have been picking for generations, and all of a sudden they don't grow there anymore," says Bill Tripp, a member of the Karuk Tribe and its director of natural resources and environmental policy.

The Karuk Tribe now tries to assign tribe representatives to accompany any fire crews on POD lines to ensure that culturally important resources are protected.

The strategy was implemented during last summer's Six Rivers National Forest Lightning Complex Fires. After a flurry of lightning strikes ignited dozens of fires across the Six Rivers National Forest and Redwood National and State Parks in August, a bout of rainfall that dampened the blazes provided land managers with safe conditions to let the fires burn on and to ignite some flames of their own.

Using PODs to identify suitable ridgelines, fire crews accompanied by cultural representatives set flames that crawled downhill to converge with the wildfires. Those strategic ignitions burned areas that the wildfires may have reached eventually, Colegrove says, but they probably burned in a gentler manner. The fire crews took advantage of a natural fire behavior; in the absence of winds, descending blazes generally move less vigorously than those going uphill. So most of the land affected by the set fires burned at low or moderate

intensity, Colegrove says. Compared with high-intensity fires, which can move fast and consume entire trees, low- and moderate-intensity fires spread slower and stick closer to the ground, clearing ground-level vegetation.

Such mild fires can be immensely beneficial. In conifer forests like the Six Rivers National Forest, low-intensity blazes reduce the risk of future high-intensity fires by about 64 percent, researchers reported last year in *Science Advances*, with the effects lasting at least six years.

Though the human-lit flames burned within 100 meters of Harling's home, he found the risk worthwhile. "After 20 years of community organizing with the Karuk Tribe and partners, the federal agencies finally gave us a chance to use beneficial fire on the landscape," he says.

Tribal consultations should be integrated into the process of treating lands within a POD, Tripp says. Simply opening the doors for those discussions will spotlight the need to build relationships, he says.

In its 2023 Tribal Action Plan, the Forest Service highlights the importance of assigning a tribal liaison to every wildfire response. Perhaps PODs could be used to illuminate where such liaisons could be most effective, Tripp says. If a POD is developed on land where there is no documented framework for collaborating with a local tribe, he says, that could provide the impetus for bringing on a liaison to build a relationship.

A new language for fire

Head to the very center of Arizona, and you will probably end up near Payson. The town is surrounded by the Tonto National Forest and by the world's largest contiguous stand of ponderosa pine. A few of those scaly-barked, droopy-needled trees are within view of Lata's office.

"We know that this area burned on average about every seven years," Lata says, referring to the time before widespread fire suppression began. So long as humans are around, that fire frequency is unlikely to return. "There aren't going to be a lot of places where we let the natural disturbance cycle play its role, because even though we now understand how important fire is … we don't have the freedom to put that much fire back in the system," she says. There's a limit to how much fire and smoke people will tolerate.

Nonetheless, PODs should help get more fire onto the landscape, and not just through the management of natural blazes. Managers of the Tonto forest use PODs to identify areas that would benefit from prescribed burning to clear away brush and thus improve wildlife habitat, reduce wildfire risk or reap other ecological benefits.

During the Six Rivers National Forest Lightning Complex Fires in 2023, fire crews lit flames to mitigate damage by naturally ignited wildfires. Here, firefighters burn brush with a drip torch to forestall a blaze that threatened a home.

W. HARLING

"It's kind of a no-brainer to use the PODs as boundaries for those projects," Lata says.

Others agree. In 2019, the San Juan National Forest of Colorado began integrating PODs into their plans for prescribed burning. That same year, the San Isabel National Forest in Colorado used a POD network to help identify where to clear brush for firebreaks that could help contain future fires. And in 2020, the Washington State Department of Natural Resources also started using PODs to prioritize such treatments and to explain to private landowners why treatments were necessary, and why certain areas were being prioritized for treatment over others.

It helps to have a tool that can show landowners why their neighbors' property should be treated first, says forest sciences researcher Cole Buettner of Colorado State University. In a 2023 study, he evaluated how PODs have been used in these "non-incident contexts," as they're called. "It can help get a lot of support for what you're doing."

Perhaps in this regard, PODs serve their most vital function. In translating visions for fire into lines and colors on a map, PODs become a communal language through which a new relationship with wildfire may be forged.

These polygons simplify the conversation, Lata says. "We can just say POD, and we all know what that means." ■

Explore more

- Xiao Wu *et al*. "Low-intensity fires mitigate the risk of high-intensity wildfires in California's forests." *Science Advances*. November 10, 2023.

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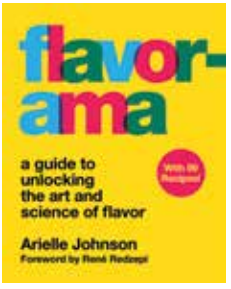
Congratulations to the Regeneron Science Talent Search top winners

On March 12, Society for Science and Regeneron announced the top winners of the Regeneron Science Talent Search (STS), the most prestigious science and math competition in the United States for high school seniors. Launched in 1942 as the Westinghouse Science Talent Search, Regeneron STS recognizes and empowers our nation's most promising young scientists who are developing ideas that could solve society's most urgent challenges.

Achyuta Rajaram (center), 17, of Exeter, N.H., won first place and $250,000. Second place and $175,000 went to **Thomas Cong** (left), 17, of Ossining, N.Y. Third place and $150,000 went to **Michelle Wei** (right), 17, of San Jose, Calif.

Rajaram, Cong and Wei participated in a weeklong competition alongside 37 other finalists. The rigorous judging process considers how the students' research, innovative thinking and leadership qualities demonstrate their potential to become future scientific leaders. In total, more than $1.8 million was awarded to the 40 finalists, who were selected from the largest entrant pool since the 1960s.



Flavorama
Arielle Johnson
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BOOKSHELF

A chemist offers a scientific approach to deliciousness

What gives a lemon its lemoniness? It's the physical molecules within the fruit. A bite into a lemon wedge sends citric acid molecules and other compounds to the tongue and through the nose, a one-two punch of the sour taste and citrusy scent that the brain senses as lemony.

Being a combination of taste and smell makes flavor a challenge for people who want to master it. There are five distinct tastes—salty, sour, sweet, umami and bitter—and the tongue has dedicated receptors for detecting molecules that correspond to each one. Smell is more complicated, with about 400 types of smell receptors in the nose that capture signals from many, many different molecules. Taken together, this means a near-infinite number of flavors exists.

> What the book teaches is how to use "flavor science as a liberating tool for improvising."

Perhaps there's no better guide to this complex landscape than Arielle Johnson. She not only has a Ph.D. in chemistry, but she also was the resident scientist at Noma, a fine-dining establishment in Copenhagen that has been named the World's Best Restaurant five times since it opened in 2003.

Johnson distills her expertise in both the kitchen and the lab in *Flavorama: A Guide to Unlocking the Art and Science of Flavor*. Complete with colorful illustrations and fun recipes, the book is a satisfying read regardless of your familiarity with science or cooking.

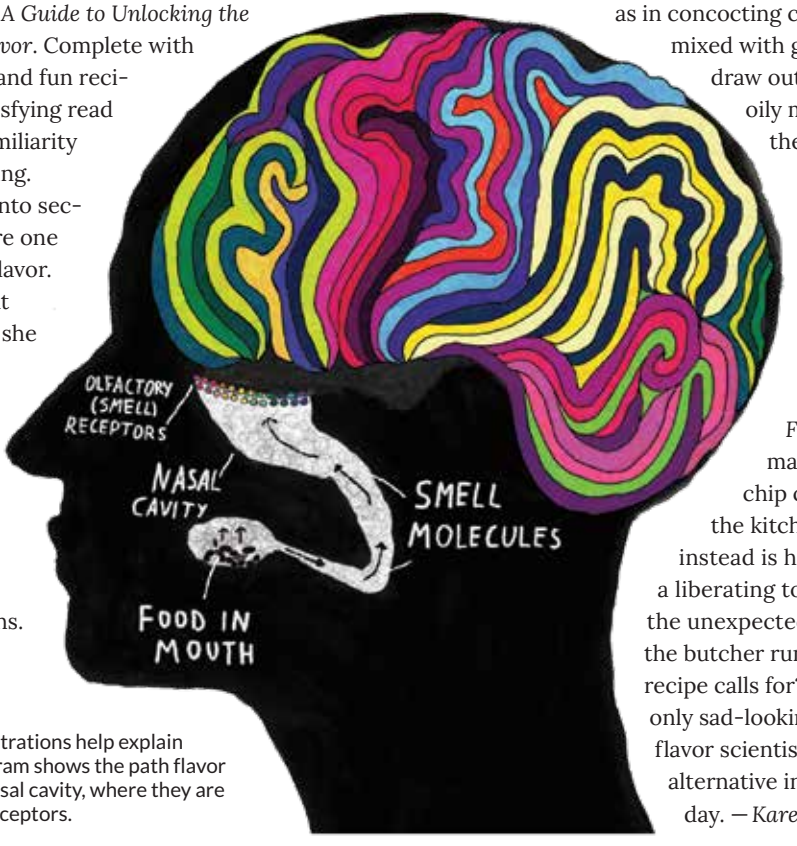
Flavorama is split into sections that each feature one of Johnson's laws of flavor. After establishing that "Flavor is molecules," she moves on to "Flavor is taste and smell." Smell, perhaps counterintuitively, often influences flavor more than taste does, thanks to the numerous smell receptors, she explains. Smell can also evoke emotional memories more intensely than other sensory inputs. Hand-drawn illustrations of the human brain and nasal cavity explain why by showing how nerve cells that line the roof of the nasal cavity detect scent molecules and send signals directly to the limbic system, a part of the brain that handles feelings and memories. Other sensory inputs, in contrast, are first processed in different parts of the brain before arriving at the limbic system.

Johnson dives deep into different tastes and smells to illustrate her next law: "Flavor follows predictable patterns." Johnson peppers recipes throughout this section to highlight each taste and smell category. One atypical recipe, umami-boosted cacio e pepe, urges readers to add anchovies and nutritional yeast to this traditional Italian pasta dish of cheese and black pepper to boost the umami flavor that can be hard for some to pinpoint. Identifying flavors is something most of us can learn to do, Johnson argues.

The next law proclaims that "Flavor can be concentrated, extracted and infused." By moving flavor molecules around selectively, you can make a flavor more intense or more diffused, and its medium more viscous or more liquid. For instance, juicing can remove flavorless solids from a tasty liquid like orange juice. The chemical principle of "like dissolves like" can help extract flavor molecules, such as in concocting compound butter. When mixed with garlic, butter and its fats draw out the aromatic ingredient's oily molecules, complementing the butter's flavor.

The book closes with the final law, "Flavor can be created and transformed," in which Johnson shows how to manipulate flavors with heat and fermentation.

Johnson would be the first to tell you that *Flavorama* will not help you make the perfect chocolate chip cookie or avoid mistakes in the kitchen. What the book teaches instead is how to use "flavor science as a liberating tool for improvising" when the unexpected inevitably happens. Did the butcher run out of the short ribs the recipe calls for? Did the grocery store have only sad-looking parsley? Thinking like a flavor scientist can help you identify an alternative ingredient that can save the day. —*Karen Kwon*



Flavorama's colorful illustrations help explain flavor science. This diagram shows the path flavor molecules take to the nasal cavity, where they are captured by olfactory receptors.

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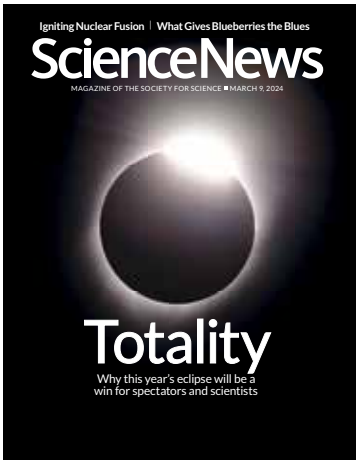

MARCH 9, 2024

Hidden depths

Slight changes in the orbit of Saturn's moon Mimas hint at the presence of a vast, young ocean beneath the satellite's icy surface that may have formed between 5 million and 50 million years ago, ***Adam Mann*** *reported in "This Saturn moon may harbor water" (*SN: 3/9/24, p. 8*).*

Reader **Bobby Baum** asked how the ocean formed so recently and whether an ocean could have formed multiple times in the past.

Saturn's moons gravitationally interact with one another and with their ringed parent planet as they orbit. This complex dance causes tidal stresses on the moons, generating heat that can melt a satellite's icy interior.

The putative ocean beneath Mimas' surface probably formed because of such an interaction with at least one of the other Saturnian moons in the recent past, says **Valéry Lainey**, an astronomer at the Paris Observatory. "We do not know yet which [other] moon is responsible for this, but such interactions are very common in celestial mechanics," **Lainey** says.

The subsurface ocean probably didn't exist earlier in Mimas' history, **Lainey** and colleagues suspect. That's because the team has not seen any evidence of surface deformations that a thick, liquid ocean would have caused.

Kids' creations?

Radiocarbon dating suggests that ancient cave paintings in Argentina are nearly 8,200 years old. That age implies that the region's rock art tradition, which probably preserved cultural knowledge shared by hunter-gatherers, is several millennia older than previous evidence suggests, ***Bruce Bower*** *reported in "Patagonian cave kept culture alive" (*SN: 3/9/24, p. 16*).*

Reader **Joan** wondered if children, rather than adults, could have created the ancient art. "I often had my children draw and paint when they could not play outside. If I was stuck in a cave with my children, they would have been painting on the walls," **Joan** wrote.

"There is no way to know for sure who made these cave paintings," **Bower** says. Some researchers have long suspected that Stone Age children and teenagers used their fingers to impress line patterns on cave walls, as well as leave behind kid- and teen-sized hand stencils inside caves (SN: 4/28/07, p. 264). "If young people made some or all of the cave paintings in Argentina, they participated in what may have been a system for transmitting cultural knowledge that lasted over 3,000 years," **Bower** says.

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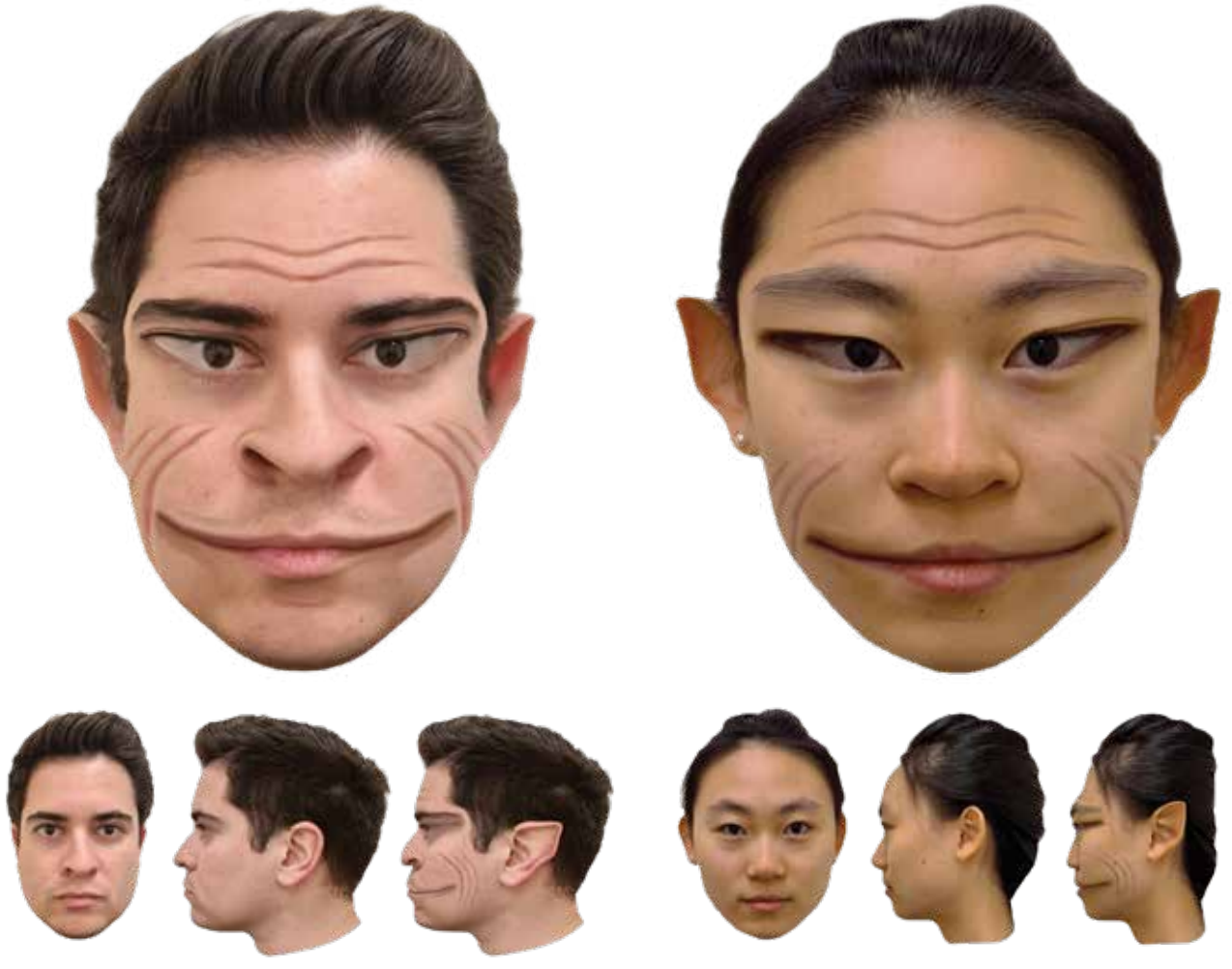

Here's what faces can look like to people with a rare visual disorder

Imagine a person's face. Now imagine that when you looked at that face, it might appear distorted. That's what life is like for someone with prosopometamorphopsia, or PMO, a rare disorder that alters the perception of faces. Thanks to a new study, you can see through the eyes of someone with this condition.

Relying on feedback from a 58-year-old man who has had PMO for nearly three years, researchers at Dartmouth College altered photos of faces to mimic the distortions he experienced. This is the first time anyone has created images that so closely replicate what a patient with PMO sees, psychologist Antônio Mello and colleagues report in the March 23 *Lancet*.

"We hope this has a big impact in the way people think about PMO, especially for them to be able to understand how severe PMO can be," Mello says.

PMO is poorly understood, with fewer than 100 cases cited since 1904. Patients report a wide variety of facial distortions. But some unusual aspects of this case allowed researchers to accurately depict what the man saw. Crucially, he sees distortions in faces viewed only in person, not in images.

By seeing a person next to a photo of that person in an identical setting, the patient could compare a distorted face with a nondistorted one. He described the differences to the researchers, who edited the image in a computer program until the patient confirmed that the altered image (some shown above along with unaltered images) matched how he saw the face.

These visualizations are patient-specific and wouldn't apply to everyone with PMO, says neurologist Jason Barton of the University of British Columbia in Vancouver. Still, "I think it's helpful for people to understand the kinds of distortions people can see."

Mello hopes the visualizations will educate clinicians about this underdiagnosed condition. His team launched a website about PMO a few years ago and has now heard from more than 70 people who have experienced facial distortions, many of whom have been misdiagnosed: The condition is often interpreted as a psychiatric problem rather than a neurological one.

When properly diagnosed, neurologists can sometimes treat the underlying trigger, such as a stroke. Still, the exact mechanisms behind the distortions remain unknown. Better understanding, Mello says, could not only help patients but also provide insight into how facial processing works. —*Anna Gibbs*

A. MELLO *ET AL*/*THE LANCET* 2024

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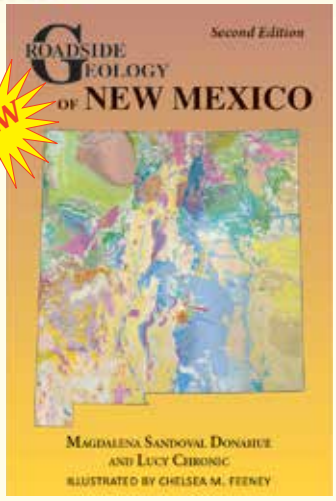

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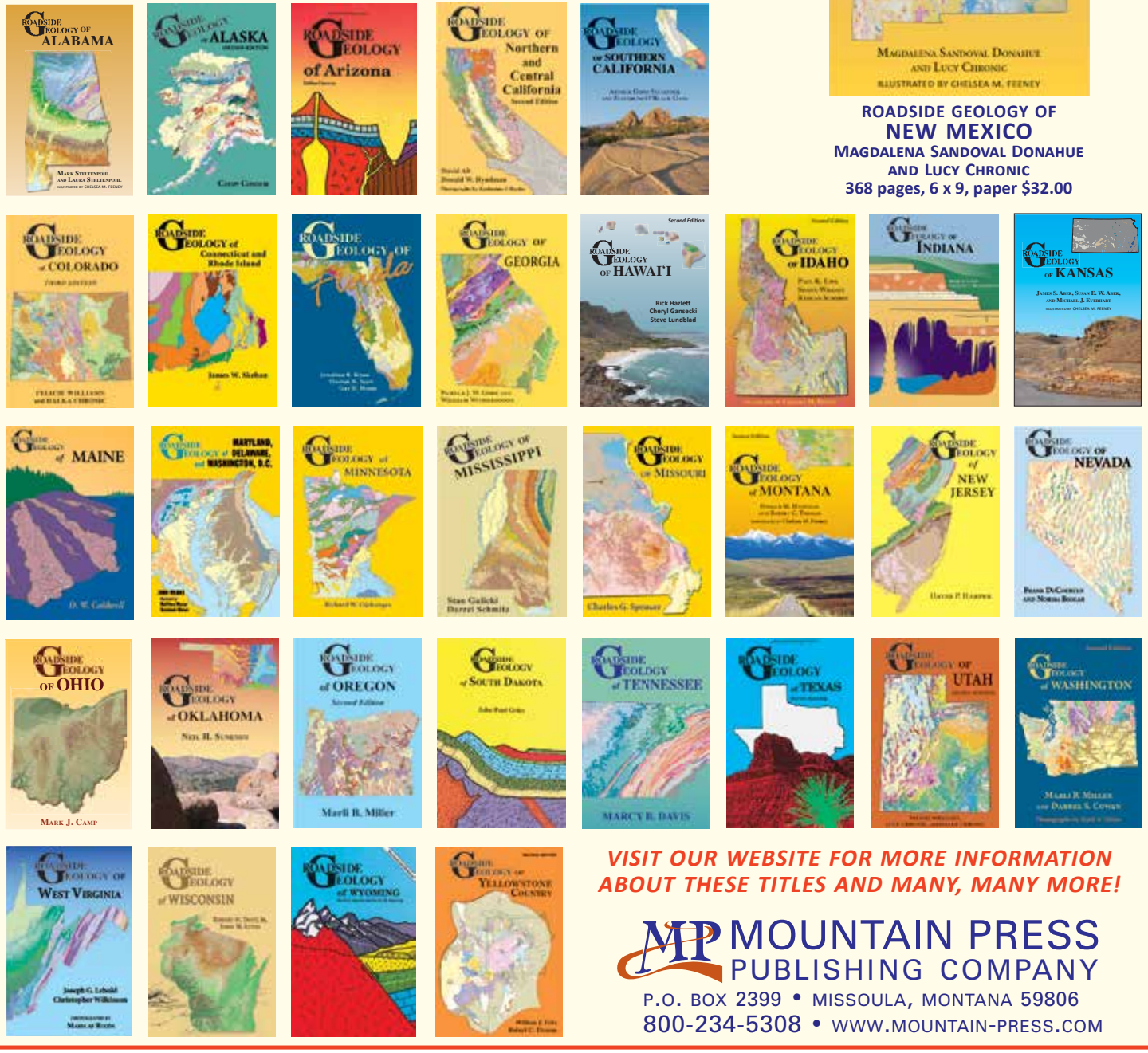

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